The Home Energy Saver

Documentation of Calculation Methodology, Input Data, and Infrastructure

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Abstract

The Home Energy Saver (HES, http://HomeEnergySaver.lbl.gov) is an interactive web site designed to help residential consumers make decisions about energy use in their homes. This report describes the underlying methods and data for estimating energy consumption. Using engineering models, the site estimates energy consumption for six major categories (end uses); heating, cooling, water heating, major appliances, lighting, and miscellaneous equipment. The approach taken by the Home Energy Saver is to provide users with initial results based on a minimum of user input, allowing progressively greater control in specifying the characteristics of the house and energy consuming appliances. Outputs include energy consumption (by fuel and end use), energy-related emissions (carbon dioxide), energy bills (total and by fuel and end use), and energy saving recommendations. Real-world electricity tariffs are used for many locations, making the bill estimates even more accurate. Where information about the house is not available from the user, default values are used based on end-use surveys and engineering studies. An extensive body of qualitative decision-support information augments the analytical results.

Acknowledgements

This project has been over a decade in the making, and has benefited from the expertise and support of many people. The tasks have ranged from creating the models and gathering the data documented in this report to building and maintaining the user interface and underlying code base. We have many clients to thank, including Terry Logee, Charles Hemmeline, and Lani MacRae (U.S. Department of Energy), Dale Hoffmeyer, Lena Nirk, Steve Offutt, and Mia South (U.S. Environmental Protection Agency), Martha Brook (California Energy Commission, Public Interest Energy Research), and Pete Schmutz (Touchstone Energy Co-operatives). Collaborators on previous versions of the website include Kerey Carter, Teresa Forowicz, Joe Huang, Clay Johnson, Joanne Lambert, Bruce Nordman, Erik Page, Brian Pon, Madeline Rosenthal, Z Smith, Peter Thiery, Gabor Torok, and Sam Webster.

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1. Introduction

The Home Energy Saver (HES, http://HomeEnergySaver.lbl.gov) is an interactive web site designed to help residential consumers make decisions about energy use in their homes. Its aims are to increase consumer interest in energy efficiency and to foster market activities that capture those opportunities. The site is developed and maintained by the Lawrence Berkeley National Laboratory with sponsorship (past and/or present) from the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and the California Energy Commission.

Development of the Home Energy Saver began in 1994, and the site first went on-line in 1996[1], originally sponsored by the ENERGY STAR program, operated by EPA and DOE (Mills 1997)[2]. The Home Energy Saver uses state-of-the-art data and models to support the Federal energy mission by helping to build national recognition of Federal energy efficiency programs and by enabling consumers to quantify the energy savings and environmental benefits that can be achieved by improving the energy efficiency of their home. The site is also used periodically by researchers, designers and contractors as a tool for analyzing residential energy performance issues, and for learning from actual homeowners about their experiences with implementing energy-saving upgrades. Finally, through the Energized Learning module, science educators at the high school and college level regularly use HES as part of their science curricula (http://EnergizedLearning.lbl.gov). As of August 2004, there are approximately 460,000 top-page visits per year. Based on a user-feedback form, submitted thus far by approximately 1100 users, approximately 80% of users are homeowners or renters, with the balance made up of those who visit for professional/educational reasons, such as building professionals, educators, contractors etc.

The Home Energy Saver provides two basic services to the residential consumer

- A calculation of energy consumption by end use, for the entire household
- Estimate of energy bills based on end use consumption, and a comparison of consumption to a "typical" household and subsequent recommendations for bill reduction.

In this report, we first provide a description of the method for calculating energy consumption, and the levels of input detail available to the user and the output reported to the user. We then describe the calculation of energy bills based on consumption. Finally, we document the presentation by which consumers can compare results for their household to households typical in their geographical area, and which suggest possibilities for energy bill reduction. The report includes appendices that describe the user interface and software/hardware architecture underlying the site[3].

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[1] An earlier version developed at LBNL was called WebCalc.

[2] In 2000, the ENERGY STAR program sponsored the development of a simplified consumer web site derived from the HES, called Home Energy Advisor (Advisor, http://hit.lbl.gov). In most cases, Advisor uses the same data and calculation methodologies as HES, but employs a more constrained building description and provides different outputs

[3] A companion report (Warner 2005) describes the use of the DOE-2.1E simulation model for handling space conditioning.

The goal in developing the Home Energy Saver web site has been to provide consumers with a simple way to use state-of-the-art residential energy calculation tools and energy data. The site integrates a variety of models, algorithms, and data sources developed over several decades at Lawrence Berkeley National Laboratory, other DOE National Labs, utilities, and elsewhere in the energy community. Historically, access to and use of such materials has required more extensive expertise and knowledge of energy and building technologies than that possessed by consumers. Making these tools and information available via a web-based interface, enables lay users to obtain energy use and savings estimates tailored to their particular home, climate, lifestyles, etc. While not discussed further here, the site also provides extensive "decision-support" information to accompany the analytical results (via the "Librarian" and "Making it Happen" modules).

Consumer-oriented home energy calculators are most effective if they combine careful energy analysis with energy cost information in a fashion that yields meaningful energy bills. Energy tariffs (particularly those for electricity) are becoming increasingly complex, as they are redesigned to encourage efficient use of energy at the margin and management of peak demand. For example, the so-called "inverted block tariffs" present the user with an increasing per-unit electricity price as consumption rises. "Time-of-Use" tariffs present the user with high electricity prices at times when the utility system is likely to be facing peak demands (e.g. weekday afternoons during summer), and correspondingly low prices at off-peak times. Most energy calculators utilize highly stylized prices (e.g. a flat cents-per-kilowatt-hour value), which fail to capture the real-world conditions facing consumers. To address this void, the Home Energy Saver site includes a process to model electricity bills using actual utility tariffs.

1.1. Limitations and Advantages of Web-based Energy Modeling

- State – Unlike a computer based application, the web based environment does not maintain a constant connection between a user and the application. For each new action, the web server must be given information to connect a user with their particular session, in the form of cookies or a session ID. If this information expires, the user is required to start the process over.
- Network Latency and Errors – the internet is a conglomeration of servers, routers and transmission paths that are largely independent of each other. Delays or lack of service in any part can make it appear to a user that our site is unavailable or slow. To a great extent, the internet compensates for outage and bottlenecks by re-routing traffic to areas with greater capacity, but some bottlenecks can't be avoided, such as the link from the user's computer to their ISP.
- User comprehension – energy modeling is a complex process, and has its share of technical language. We've attempted to use common language in parsing inputs and results, but misunderstandings and confusion can still occur. The lack of a trained professional on hand to assist may limit some users experience.

Advantages include ease of distribution, version control, platform independence and the ability to locate computation-intensive simulation engines such as DOE-2 on a central (free to the public) server, rather than requiring users to install and administer them on home personal computers.

2. User Interface

The Home Energy Saver was the first Internet-based tool for calculating energy use in residential buildings. The approach taken by the web site is to provide users with results based on a minimum of user input, and then, for those interested in continuing, allowing them progressively greater degrees of control in specifying the house and energy consuming appliances characteristics. This allows users with limited knowledge or time to access results that are generally applicable to their situation, while more informed or persistent users can get greater accuracy and relevance by customizing their house description. This design philosophy results in a progressive three-tiered approach to estimating energy consumption.

At the initial level of inputs, users are asked solely for their zip code (Figure 1). An initial set of results are immediately derived from the zip code input. These results are averages for the housing stock in their region, based on the 2001 Residential Energy Consumption Survey (RECS) (US DOE. 2004). HES also presents potential savings for a typical house in that region.

Simultaneously, users are shown the questions for the second, “simple inputs” level of the Home Energy Saver (Figure 2). This set of questions focuses on those appliances and housing characteristics that cause large variance in energy consumption (e.g. floor area, heating equipment, etc.). These key inputs can be used to refine the energy estimation further.

After answering the questions in the “simple inputs” level of HES, users can either calculate the energy used by their house (Figures 3 to 5) based on the description provided by the “simple level” of questions or further refine the house description before calculating by accessing the third, “detailed inputs” level of the model. In the detailed input pages, they can adjust nearly all of the envelope, site and appliance characteristics that go into estimating energy consumption for their home.

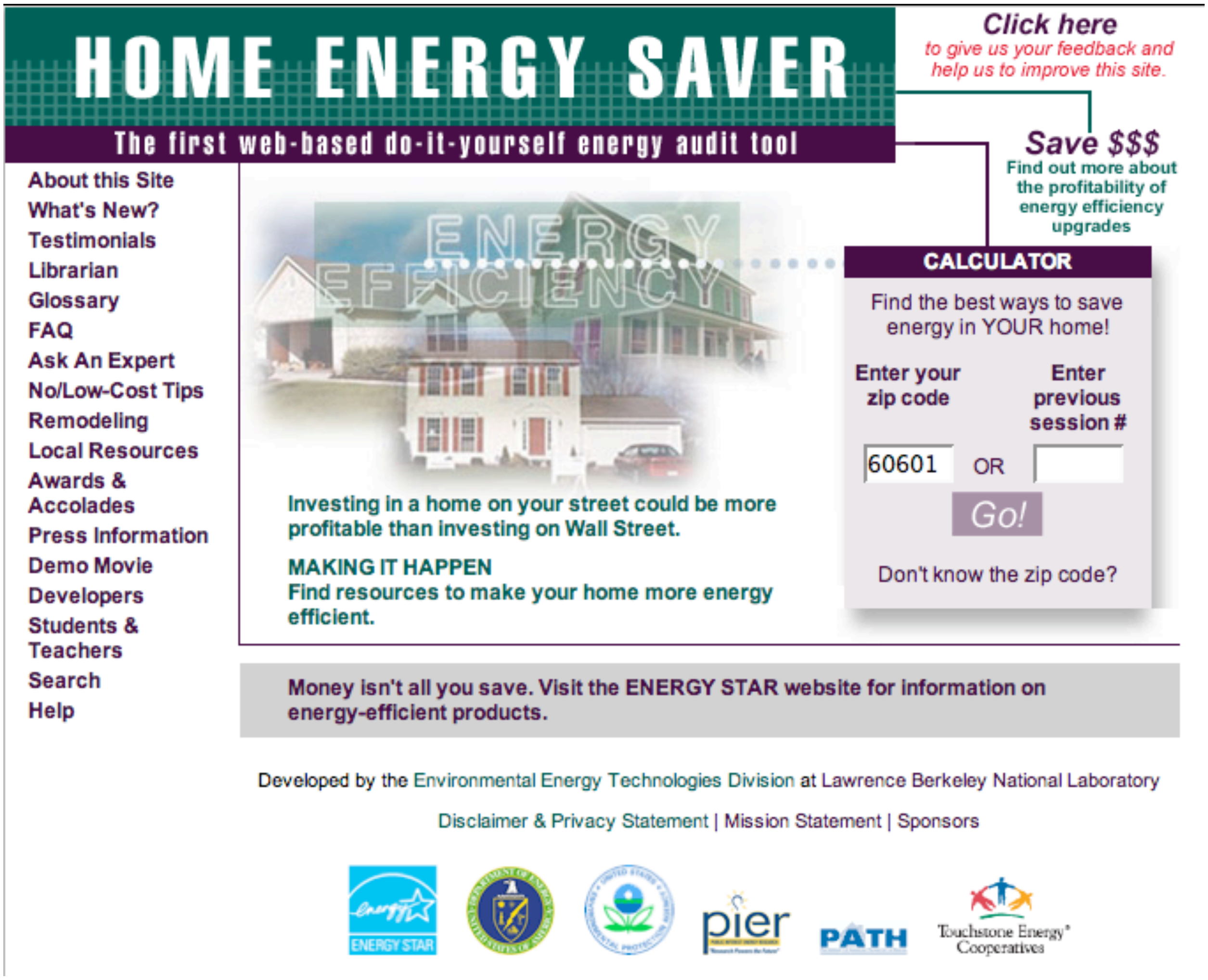
When the user is satisfied with the house description, they calculate the energy consumption, which replaces the prior default results based on a house in their area. At this time they can also view more detailed reports (Figures 6 and 7).

For both the “simple inputs” and “detailed inputs” levels, the models used to estimate energy consumption are identical, with user-entered values substituting for default values as the user progresses through the “detailed inputs” level. There are six major categories (end-uses) where energy consumption is estimated; heating, cooling, water heating, major appliances, lighting, and miscellaneous equipment. The Home Energy Saver uses engineering models to estimate energy consumption for all these end-uses.

2.1 Entry Page

The entry point to the calculation process is through the main page of the Home Energy Saver website. In addition to all of the informational content about energy efficiency, the users can choose to enter their ZIP code and initiate a session, or enter their session number from a previous visit, which will return them to the results of that session.

Figure 1. Entry Page for Home Energy Saver Website.



2.2. Initial "Simple" Inputs Page with ZIP-Code-Based Bill

After entering a zip code, the users see the first page, which shows the average energy consumption for a typical house in their area, taken from the Residential Energy Consumption Survey (RECS) (US DOE 2004), see Section 4.1 for details on how this average bill was generated. The lower half of the screen shows the questions for the "simple" level of calculation (Figure 2). Users have the choice of calculating the bill for their house, based on those questions, or providing more detail about their house before calculating. By answering the detailed questions (below the bar chart in Figure 2), users get results calculated using a house description that more closely matches their house.

Figure 2. Initial "Simple" Inputs Page with ZIP-Code-Based Bill.

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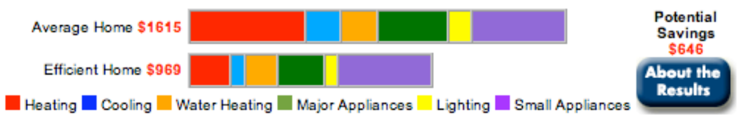
General Info Heading & Cooling Water Heating Major Appliances Small Appliances Lighting

Energy Bill for Homes in Chicago, Illinois

Based on the zip code you entered, here is a comparison of the energy costs (in $/year) of an average home and an energy-efficient home in your area.



See greenhouse gas emissions and energy consumption What should I do next?

Save Answers... You can estimate you energy bill immediately (by pressing the "Save Answers" button), or customize your house description using the links below.

1. Upgrade Calculation:

   What simple payback period would you like to use for selecting upgrades? 10 years

   What efficiency level would you like to model for the initial selection of upgrades? Energy Star / DOE recommended
   (you'll be able to individually adjust the efficiency of each upgrade later)

2. Which city has the most similar climate to your house? Chicago
3. Year your house was built: 1960
4. What is the conditioned floor area: 1800 sq. ft.
5. How many stories above ground level are there? 2
6. The front of your house faces: North
7. What type of foundation does your house have? Conditioned Basement
8. How much attic floor or roof insulation do you have? R-11 (4-6 inches)
9. Does your house have wall insulation? Yes No/Don't Know
10. Does your house have foundation or floor insulation? Yes No/Don't Know
11. Do you have a clothes washer? Have Don't Have
12. How many refrigerators do you have? 1 Refrigerator
13. How many freezers do you have? No Standalone Freezers
14. What is your water heater fuel? Natural Gas
15. What kind of heating equipment do you have? Central Gas furnace
16. What kind of cooling equipment do you have? Central air conditioner
17. Starting with the front of your house, how many windows are on each side
(Assume each window is 12 square feet)

Front: 6 Left: 3 Back: 6 Right: 3

18. What price do you pay for your energy?
Consult your utility bills to update the statewide averages shown below.
For electricity prices, you may either use the statewide average, or select an electricity tariff.
Note that all fuels must have a price. If you do not use a particular fuel leave the default value in place,
The price for unused fuels will not effect your results.

Electricity	Piped Natural Gas	0.733	$/therm or $/100 cubic foot
Use Average price per kWh 0.085 $/kilowatt-hour	Liquid Propane Gas	1.091	$/gallon
Select an electricity tariff (Click Save, a new page will open with a list of utilities)	Fuel Oil	1.164	$/gallon

19. Please tell us how many people living in your house fall into the following groups:
0 0 to 5 years 1 6 to 13 years 2 14 to 64 years 0 65 years and older

Save Answers

(**Note**: Your session number is 893788. Please record this number for future access to the information you enter here. To access a previously created session, enter the session ID in the form on the top page.)

2.3. Error Handling

2.3.1 User Input Validations

Where appropriate, the user interface is designed with javascript and occasionally using server-side input validations to ensure that the answer submitted by the user is valid. There are two main types of javascript validations, the first prevents non-valid characters from being typed into text boxes (e.g. alphabetic characters not allowed in an integer text field), while the second checks the final value against the allowable range (e.g. percentage values must be between 0% and 100%). Additionally in a few instances, there are server side validations that check inputs for more complicated problems (e.g. window area is greater than wall area when framing members and area of doors is included). When an error is noted, a message is displayed to the user, identifying the problem and asking them to correct their inputs.

2.3.2 Failures in the DOE-2.1 Calculation

On occasion, a dropped network connection or an inappropriate house description can cause the DOE-2 engine to experience failure. The Home Energy Saver has error traps in place to prevent the loss of data in a situation where there is a DOE-2 failure. After the results of the DOE-2 run are returned to the web application, the returned energy consumptions are tested for valid values. If an error is detected, the web application discards the returned values, continuing the calculation with the previous energy consumptions for heating and cooling. If results are not returned from DOE, the application again reverts to previously stored data.

2.4. Results Page

After the energy calculations are complete, users are presented with a new page showing the condensed results of the calculation (Figure 3). The top half of the page now contains results generated from their house description (rather than a typical house in their area). The more detailed results page (Figure 4) shows a list of possible retrofits for their house, based on the current house description, ranked by payback time, as well as links to tips and other reports about the user's energy use and information on how to save energy. Subsidiary pages show monthly energy use by major end use and electricity by time-of-use (TOU) period (for cases where the user has specified a TOU tariff (Figure 5).

Figure 3. Condensed Results Page.

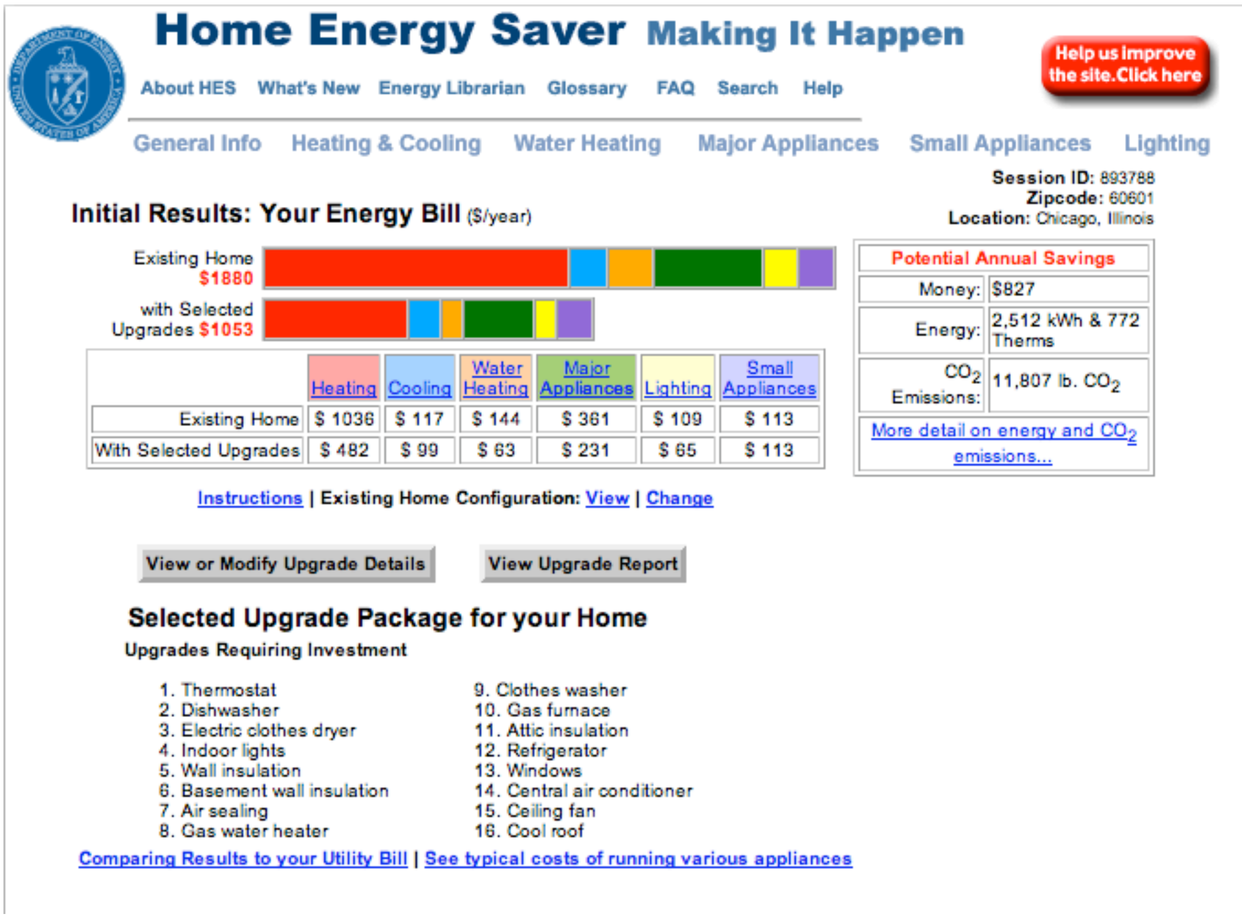
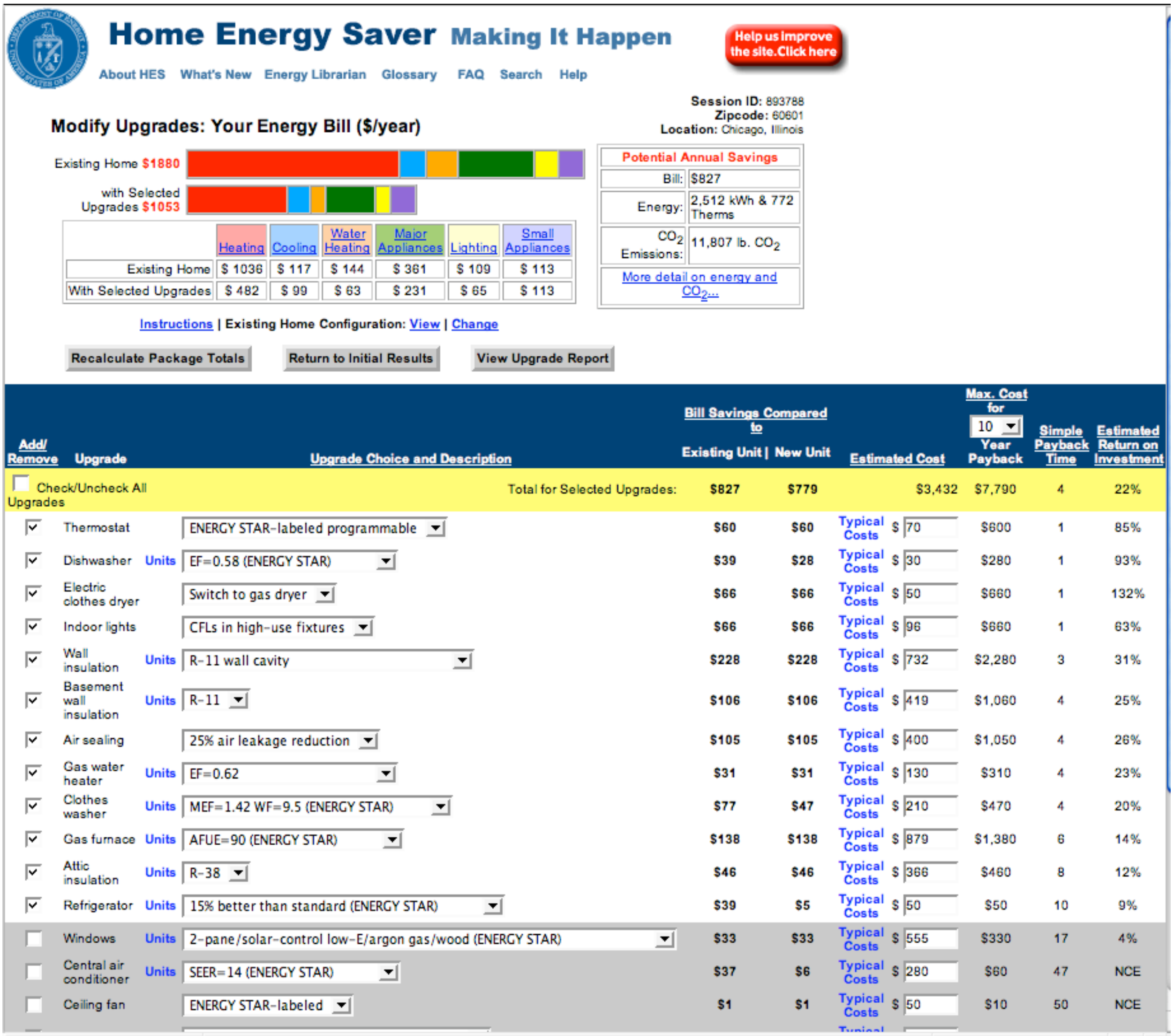


Figure 4. Detailed Results Page: Energy Savings and Economics.



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Session ID: 893788
Zipcode: 60601
Location: Chicago, Illinois

Modify Upgrades: Your Energy Bill ($/year)

Existing Home $1880

with Selected Upgrades $1053

	Heating	Cooling	Water Heating	Major Appliances	Lighting	Small Appliances
Existing Home	$ 1036	$ 117	$ 144	$ 361	$ 109	$ 113
With Selected Upgrades	$ 482	$ 99	$ 63	$ 231	$ 65	$ 113

Potential Annual Savings	
Bill:	$827
Energy:	2,512 kWh & 772 Therms
CO_2 Emissions:	11,807 lb. CO_2

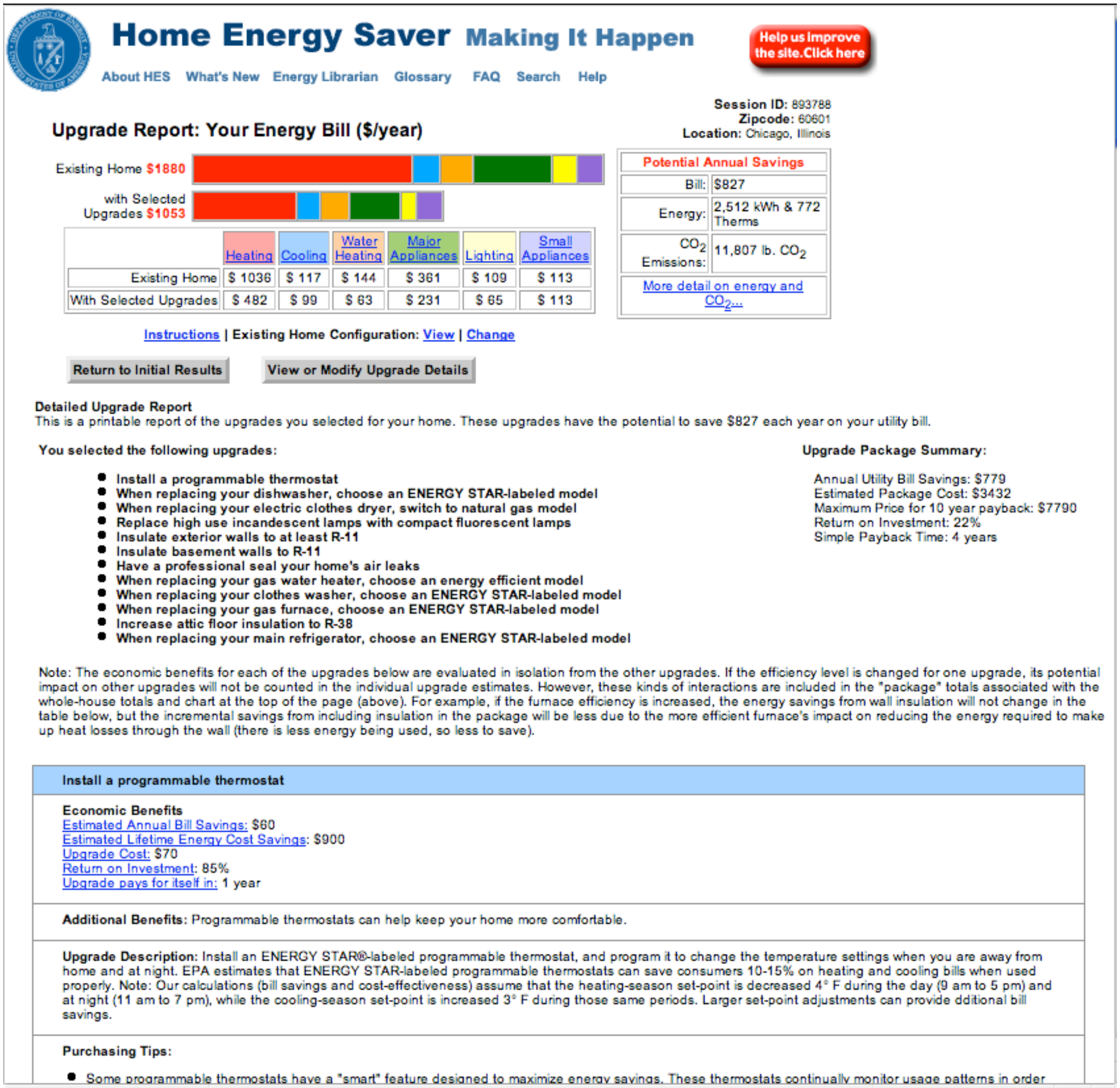
More detail on energy and CO_2...

Instructions | Existing Home Configuration: View | Change

Recalculate Package Totals | Return to Initial Results | View Upgrade Report

Add/ Remove	Upgrade		Upgrade Choice and Description	Bill Savings Compared to Existing Unit	Bill Savings Compared to New Unit		Estimated Cost	Max. Cost for 10 Year Payback	Simple Payback Time	Estimated Return on Investment
Check/Uncheck All Upgrades			Total for Selected Upgrades:	$827	$779		$3,432	$7,790	4	22%
☑	Thermostat		ENERGY STAR-labeled programmable	$60	$60	Typical Costs	$ 70	$600	1	85%
☑	Dishwasher	Units	EF=0.58 (ENERGY STAR)	$39	$28	Typical Costs	$ 30	$280	1	93%
☑	Electric clothes dryer		Switch to gas dryer	$66	$66	Typical Costs	$ 50	$660	1	132%
☑	Indoor lights		CFLs in high-use fixtures	$66	$66	Typical Costs	$ 96	$660	1	63%
☑	Wall insulation	Units	R-11 wall cavity	$228	$228	Typical Costs	$ 732	$2,280	3	31%
☑	Basement wall insulation	Units	R-11	$106	$106	Typical Costs	$ 419	$1,060	4	25%
☑	Air sealing		25% air leakage reduction	$105	$105	Typical Costs	$ 400	$1,050	4	26%
☑	Gas water heater	Units	EF=0.62	$31	$31	Typical Costs	$ 130	$310	4	23%
☑	Clothes washer	Units	MEF=1.42 WF=9.5 (ENERGY STAR)	$77	$47	Typical Costs	$ 210	$470	4	20%
☑	Gas furnace	Units	AFUE=90 (ENERGY STAR)	$138	$138	Typical Costs	$ 879	$1,380	6	14%
☑	Attic insulation	Units	R-38	$46	$46	Typical Costs	$ 366	$460	8	12%
☑	Refrigerator	Units	15% better than standard (ENERGY STAR)	$39	$5	Typical Costs	$ 50	$50	10	9%
☐	Windows	Units	2-pane/solar-control low-E/argon gas/wood (ENERGY STAR)	$33	$33	Typical Costs	$ 555	$330	17	4%
☐	Central air conditioner	Units	SEER=14 (ENERGY STAR)	$37	$6	Typical Costs	$ 280	$60	47	NCE
☐	Ceiling fan		ENERGY STAR-labeled	$1	$1	Typical Costs	$ 50	$10	50	NCE

Figure 5. Detailed Results Page: Purchasing Tips.



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Session ID: 893788
Zipcode: 60601
Location: Chicago, Illinois

Upgrade Report: Your Energy Bill ($/year)

Existing Home $1880

with Selected Upgrades $1053

	Heating	Cooling	Water Heating	Major Appliances	Lighting	Small Appliances
Existing Home	$ 1036	$ 117	$ 144	$ 361	$ 109	$ 113
With Selected Upgrades	$ 482	$ 99	$ 63	$ 231	$ 65	$ 113

Potential Annual Savings	
Bill:	$827
Energy:	2,512 kWh & 772 Therms
CO_2 Emissions:	11,807 lb. CO_2
More detail on energy and CO_2...	

Instructions | Existing Home Configuration: View | Change

Return to Initial Results | View or Modify Upgrade Details

Detailed Upgrade Report
This is a printable report of the upgrades you selected for your home. These upgrades have the potential to save $827 each year on your utility bill.

You selected the following upgrades:

- **Install a programmable thermostat**
- **When replacing your dishwasher, choose an ENERGY STAR-labeled model**
- **When replacing your electric clothes dryer, switch to natural gas model**
- **Replace high use incandescent lamps with compact fluorescent lamps**
- **Insulate exterior walls to at least R-11**
- **Insulate basement walls to R-11**
- **Have a professional seal your home's air leaks**
- **When replacing your gas water heater, choose an energy efficient model**
- **When replacing your clothes washer, choose an ENERGY STAR-labeled model**
- **When replacing your gas furnace, choose an ENERGY STAR-labeled model**
- **Increase attic floor insulation to R-38**
- **When replacing your main refrigerator, choose an ENERGY STAR-labeled model**

Upgrade Package Summary:

Annual Utility Bill Savings: $779
Estimated Package Cost: $3432
Maximum Price for 10 year payback: $7790
Return on Investment: 22%
Simple Payback Time: 4 years

Note: The economic benefits for each of the upgrades below are evaluated in isolation from the other upgrades. If the efficiency level is changed for one upgrade, its potential impact on other upgrades will not be counted in the individual upgrade estimates. However, these kinds of interactions are included in the "package" totals associated with the whole-house totals and chart at the top of the page (above). For example, if the furnace efficiency is increased, the energy savings from wall insulation will not change in the table below, but the incremental savings from including insulation in the package will be less due to the more efficient furnace's impact on reducing the energy required to make up heat losses through the wall (there is less energy being used, so less to save).

Install a programmable thermostat

Economic Benefits
Estimated Annual Bill Savings: $60
Estimated Lifetime Energy Cost Savings: $900
Upgrade Cost: $70
Return on Investment: 85%
Upgrade pays for itself in: 1 year

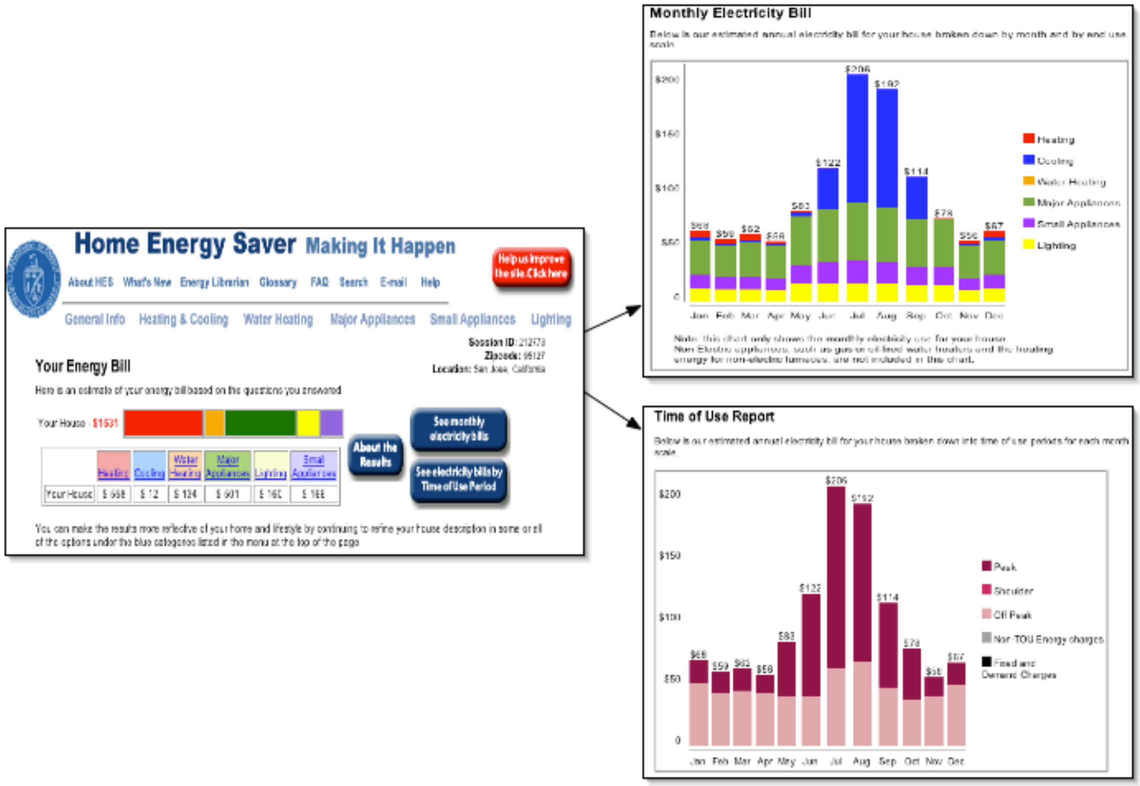
Additional Benefits: Programmable thermostats can help keep your home more comfortable.

Upgrade Description: Install an ENERGY STAR®-labeled programmable thermostat, and program it to change the temperature settings when you are away from home and at night. EPA estimates that ENERGY STAR-labeled programmable thermostats can save consumers 10-15% on heating and cooling bills when used properly. Note: Our calculations (bill savings and cost-effectiveness) assume that the heating-season set-point is decreased 4° F during the day (9 am to 5 pm) and at night (11 am to 7 pm), while the cooling-season set-point is increased 3° F during those same periods. Larger set-point adjustments can provide dditional bill savings.

Purchasing Tips:

- Some programmable thermostats have a "smart" feature designed to maximize energy savings. These thermostats continually monitor usage patterns in order

Figure 6. HES Monthly and Time-of-Use Results Pages.



2.5 Summary Reports

Additional detail is provided on the Summary Report pages. This is where detailed information, such as carbon emissions (Figure 6) or the energy consumption and bill attributable to a single appliance can be found (Figure 7).

Figure 7. Sample Summary Report (Carbon Emissions, as CO_2).

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Detail of Whole House Annual Energy Use

		Your House	With Selected Upgrades	Savings
Whole House	$	$1,880	$1,053	**$827**
	Energy	7,652 kWh & 1,678 Therms	5,139 kWh & 906 Therms	**2,512 kWh & 772 Therms**
	Emissions	28,094 lb. CO_2	16,287 lb. CO_2	**11,807 lb. CO_2**
Heating	$	$1,036	$482	**$554**
	Energy	483 kWh & 1,358 Therms	359 kWh & 616 Therms	**124 kWh & 742 Therms**
	Emissions	16,401 lb. CO_2	7,595 lb. CO_2	**8,806 lb. CO_2**
Cooling	$	$117	$99	**$18**
	Energy	1,373 kWh	1,168 kWh	**205 kWh**
	Emissions	1523 lb. CO_2	1,296 lb. CO_2	**227 lb. CO_2**
Hot Water	$	$144	$63	**$81**
	Energy	320 Therms	210 Therms	**110 Therms**
	Emissions	3,739 lb. CO_2	2,453 lb. CO_2	**1,285 lb. CO_2**
Major Appliances	$	$361	$231	**$130**
	Energy	3,178 kWh	1,509 kWh & 80 Therms	**1,669 kWh & (80) Therms**
	Emissions	3,526 lb. CO_2	2,608 lb. CO_2	**918 lb. CO_2**
Lighting	$	$109	$65	**$44**
	Energy	1,286 kWh	772 kWh	**514 kWh**
	Emissions	1,427 lb. CO_2	856 lb. CO_2	**570 lb. CO_2**
Misc.	$	$113	$113	**$0**
	Energy	1,332 kWh	1,332 kWh	**0 kWh**
	Emissions	1,478 lb. CO_2	1,478 lb. CO_2	**0 lb. CO_2**

Figure 8. Energy Consumption and Bill by End-Use (Appliances and Water Heating).

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Appliance and Water Heating Consumption Here is the approximate energy consumed in a typical year, by your major appliances.

Appliance	Appliance Energy		Water Heating Energy			Total Energy	Total Cost
	Energy per Year	Cost per Year	Water Use (gal/day)	Energy per Year	Cost per Year		
First Refrigerator:	858 kWh	$ 73	none	none	none	858 kWh	$ 73
Stove:	365 kWh	$ 31	none	none	none	365 kWh	$ 31
Oven:	239 kWh	$ 20	none	none	none	239 kWh	$ 20
Clothes Dryer:	1456 kWh	$ 124	none	none	none	1456 kWh	$ 124
Clotheswasher	98 kWh	$ 8	21	96 therms	$ 70	98 kWh & 96 therms	$ 79
Dishwasher Total	162 kWh	$ 14	6	28 therms	$ 21	162 kWh & 28 therms	$ 34
Hot Water: Taps and Faucets	none	none	43	196 therms	$ 144	196 therms	$ 144
Totals	3178 kWh	$ 270	70 gallons	320 therms	$ 235	3178 kWh & 320 therms	$ 505

Appliance energy is the energy used by motors, heating elements, and burners inside your appliances. This number excludes the energy consumed by your water heater to supply hot water for appliances such as clothes washers and dishwashers.

What if my results don't match my energy bill?

3. Calculation of Energy Consumption

For both the "simple inputs" and "detailed inputs" levels, the models used to estimate energy consumption are identical, with user-entered values substituting for default values as the user progresses through the "detailed inputs" level. There are six major categories (end-uses) where energy consumption is estimated; heating, cooling, water heating, major appliances, lighting, and miscellaneous equipment. The Home Energy Saver uses engineering models to estimate energy consumption for all these end-uses.

Table 1. Comparison of "Simple Inputs" Level vs. "Detailed Inputs" Level

Major End-Use	**Simple Inputs Level**	**Detailed Inputs Level**
Heating and Cooling	City with similar climate House construction year Conditioned floor area Stories above ground level Orientation Foundation type Ceiling/floor/wall insulation Heating/cooling equipment Window area (each side of house) Number of occupants in age groups (also affects water heating)	Approximately 80 additional questions about house shape & size; exterior shading; air-tightness; foundation & floor; walls; doors & windows; skylights; attic & roof; ducts & boiler pipes; thermostat details; heating & cooling equipment (efficiency, vintage, etc.)
Water Heating	Water heater fuel	Eight additional questions about temperature settings, water heater location and specifics, etc.
Major Appliances	Number of refrigerators (1-3) Number of freezers (0-2) Presence of clothes washer	Specific details about the refrigerators and freezers specified in the simple level; 8 questions about cooking and your dishwasher; 5 questions about clothes washers/dryers; 8 questions about hot tubs, spas and pumps
Lighting	No questions	Two levels – 1st asks for the number of fixtures/room, energy consumption/fixture defaulted based on TPU study, 2nd asks for detains on the number of bulbs, bulb type, total wattage and usage for each fixture.
Small Appliances	No questions	Roughly 50 questions about entertainment, home office, misc. kitchen appliances and other appliances.

The Home Energy Saver utilizes data from a variety of sources to provide default input values and energy consumption. The bulk of the data compilation for the Home Energy Saver was completed in 1997-1999, and the most current data available at that time was used. For time-sensitive series such as equipment efficiencies, the final data point has been used to provide values for subsequent years. The only exception to this is for the state energy prices, which have been updated to use the most current data available at the time of this report.

3.1 Heating and Cooling Calculation

This section deals with the determination of heating equipment efficiencies, thermal distribution (air or hydronic) efficiencies, infiltration, and thermostat management. The energy consumption for most types of heating and cooling equipment is estimated using the DOE-2 building simulation program (version 2.1E), developed by the U.S. Department of Energy (Birdsall et al., 1990). A companion report (Warner 2005) describes the thermodynamic modeling of the home, and the relevant characterizations of the building's thermal envelope (windows, insulation, etc.) The program performs a sophisticated series of calculations, modeling the energy consumption in the user's house in a full annual simulation for a typical weather year (involving 8760 hourly calculations). Users can choose from approximately 285 weather locations around the United States. Energy use for some heating and cooling equipment types are estimated independently of DOE-2 and are documented in this report. Interactions between space-conditioning equipment and the waste heat from occupants and appliances are also treated in the modeling process.

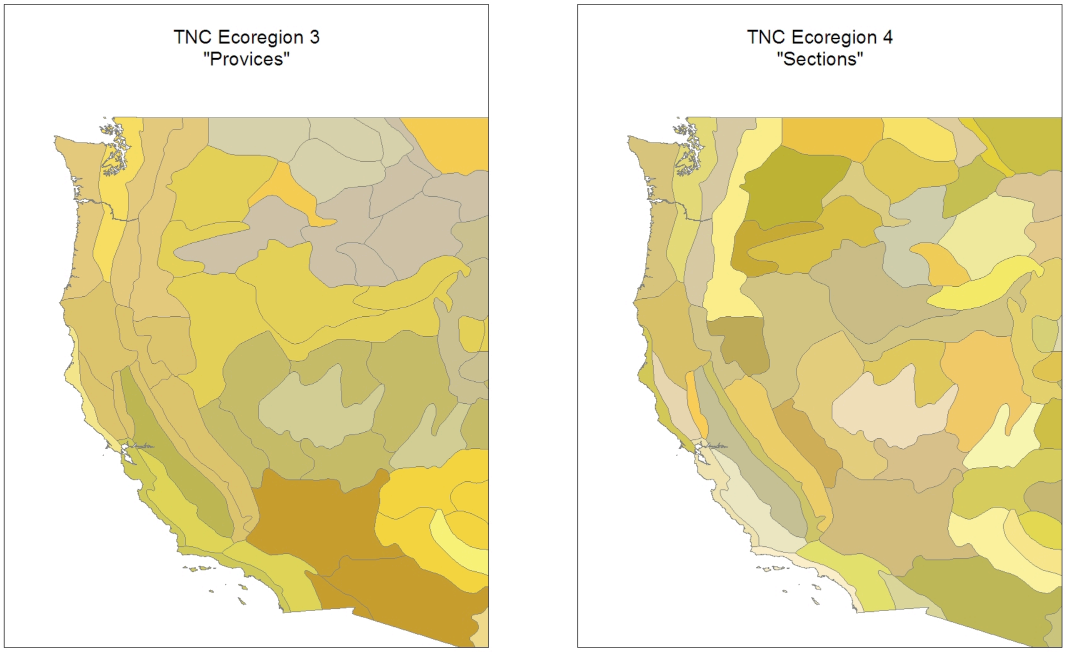
User inputs (or defaulted values, where user-entered values aren't available) are gathered together and sent to the DOE 2.1E model to calculate the heating and cooling (and water heating if user specified that water heating was tied to a central boiler system) energy consumption. The DOE 2.1E model requires inputs on the location (longitude, latitude, altitude, etc.) and climate (a specified "weather city" corresponding to a TMY, TMY2 or CTZ weather tape) of the house; general information about the house (orientation, stories above ground level, ceiling height, house shape and dimensions, etc.); construction details about the house (roof/ceiling/wall/floor/foundation construction details; type, size, shading and location of windows, skylights and doors; external shading (garage location, size of surrounding trees); details on the heating and cooling equipment (equipment type, efficiency, duct location, thermostat type and settings); and information about occupants and other sources of internal gains.

3.1.1 Weather Modeling

When users enter their ZIP code, they are assigned a default city to provide a weather data file for DOE-2 modeling. This assignment was done using a geographic information system (GIS) analysis to locate ZIP codes that are "closest" to cities with associated weather data (Weather Cities). These Weather Cities are listed in Appendix C. To represent the climatic variation across the U.S., we used The Nature Conservancy (TNC) "Ecoregions" (TNC 2001) to associate each Zip Code with an appropriate Weather City based on climate and environment, as well as linear distance.

The Nature Conservancy has created a set of GIS layers delineating EcoRegions on four different scales. The two smallest scales — the Province and the Section — were used in this analysis. These EcoRegions describe areas with relatively homogeneous environmental factors such as temperature, precipitation, humidity, vegetation, and landscape features. While not all these factors are directly related to building energy use, the predominant factors are climate-related and thus highly correlated with building energy use. On visual inspection, we also chose to use the EcoRegions because they correlate well with other climate regions used in energy analysis (e.g., the CEC climate zones) and are available nationally at a fine spatial scale. See Figure 8 for examples of the EcoRegions used in this analysis. See http://www.fs.fed.us/institute/ecolink.html for further description of the ecoregion concept. ZIP code boundary data were obtained from the U.S. Census Bureau (2004)

Figure 9. Example EcoRegions in the Western U.S.



Source: . (TNC 2001).
Note that Sections (right) are subdivisions of Provinces (left).

To assign ZIP codes, we found the closest Weather City that is also within the same Ecoregion as that ZIP code. For each ZIP code, we first tried to do this matching at the Ecoregion "Section" (smallest scale) level, but if there was no matching Weather City we would then match at the Province level. If no match was possible at the Province level, we simply used the closest weather city (in geographic distance). Distances were based on ZIP code centroid to city center. Finally, the matches were reviewed and adjusted manually.

For use in modeling water heating energy consumption, we estimate the annual average inlet water temperature (from the domestic water system) by subtracting 2˚F from the annual average dry-bulb air temperature reported in the weather data files. Inlet water temperatures in Alaska were constrained to be greater than 32 degrees Farenheit. These values are listed in Appendix C.

Summary weather statistics for each weather data file were calculated using the DOE-2 weather packing routines. These summary statistics include seasonal heating and cooling degree-days, winter and summer design-day conditions, and weather-station location data. DOE-2 utilizes the full TMY2 weather tape, extracting solar gains (insolation) and other needed information for use in the annual simulation.

3.1.2 Default House Characteristics

To assist users with describing the characteristics of their house, when users first enter the Home Energy Saver site, they are assigned default house characteristics based on the Census Division in which their ZIP code is located. These default characteristics were developed by analyzing the 1993 and 2001 Residential Energy Consumption Survey (RECS) microdata[4] (US DOE 1995a, US DOE 2004). Consumption and characteristics are based on RECS 2001 supplemented by lighting and electrical cooking consumptions from RECS 1993. All analysis is based on a subset of homes; mobile homes and single family homes (both attached and unattached). Where a house characteristic can only have discrete values (e.g., type of heating fuel or presence of dishwasher), we tabulated the saturation of that characteristic in the RECS data set and selected the most common value. For example, if natural gas was the most common heating fuel in a region, then the default house is assumed to use natural gas for heating. Appendix A. Default House Characteristics contains the default input values for each census division. For the remaining characteristics for the house, a single value was applied across all divisions. Table A-2 contains these nation-wide default housing characteristics. Default house shell characteristics, for use in DOE-2, are described in the DOE-2 companion report (Warner 2005).

3.1.3 Heating and Cooling Equipment

The Home Energy Saver web site models the following heating and cooling equipment types:

Table 2. Heating and Cooling Equipment

Equipment Type	Calculation	Default Efficiency*	Default Capacity	Default Usage
Heating				
Central Gas furnace	DOE-2	78	**	***
Room (through-the-wall) Gas furnace	DOE-2	65.6	**	***
Propane (LPG) furnace	DOE-2	78	**	***
Oil furnace	DOE-2	80	**	***
Electric furnace	DOE-2	98	**	***
Electric heat pump (heating)	DOE-2	7.0 HSPF	**	***
Electric baseboard heater	DOE-2	98	**	***
Gas boiler	DOE-2	80	**	***
Oil boiler	DOE-2	80	**	***
Cooling				
Central air conditioner	DOE-2	9.5 SEER	**	***
Room air conditioner	$\left(\frac{\left(\frac{capacity \times hours/day \times days/year}{efficiency}\right)}{1000}\right) \times 0.003412$	9.0 EER	13,000 Btu/hr	Hrs/day=5, Days=99
Electric heat pump (cooling)	DOE-2	9.5 SEER	**	***
Whole house fan	$power_{fan} \times hours/day \times 30 \times months$	$power_{fan}$=0.3 kWh; hours/day=2; months=2		
Ceiling fan	$50kWh \times number_{fans}$	$Number_{fans}$=2		
Portable fan	$22kWh \times number_{fans}$	$Number_{fans}$=2		

[4] Microdata are the household-level data from each of the houses in the RECS sample.

*Default Efficiency is AFUE unless otherwise indicated.
** Capacity for this equipment type is automatically calculated in the DOE-2.1 model.
*** Usage for this equipment type is calculated in the DOE-2.1 model, based on user-specified thermostat settings and schedule (see below)
Note: DOE-2.1 models both electricity and other fuel usage for equipment types with multiple fuels (e.g. Central Gas Furnaces, which use natural gas for heating and electricity use by the air-handler fan).

For those equipment types modeled in DOE-2, the equipment characteristics (default values taken from Table 1) are input to the DOE-2 model. Energy consumption in million BTUs is returned from DOE-2 and converted to the units in which the consumer would purchase the fuel, using the fuel-specific conversion factors found in Table 3.

Table 3. Fuel Conversion Factors – BTUs to Consumer-purchasing Units

Fuel	Conversion factor (site energy)
Electricity	3412.76 BTU/kWh
Natural Gas	100,000 BTU/therm
Liquid Propane	91,500 BTU/gallon
Fuel Oil	138,690 BTU/gallon

3.1.3.1 Heating Equipment Efficiency

In the detailed inputs level of the model, users can select the purchase year for their heating and cooling systems as an alternative to entering an efficiency value for the equipment. In these cases, we derive a shipment-weighted efficiency based on the purchase year of the equipment (Table 4 and Table 5). A shipment-weighted efficiency is the average efficiency for all units sold within a particular year weighted by the number of units in each efficiency bin (AHAM 1996). Efficiencies for furnaces are measured as AFUE, or Annual Fuel Utilization Efficiency rating, which represents the seasonal or annual efficiency of the furnace. Heat pumps efficiency is shown as HSPF, Heating Seasonal Performance Factor.

Table 4. Shipment Weighted Efficiencies for Heating Equipment

Year	Electric Furnace (AFUE)	Electric Heat Pump (HSPF)	Gas Boiler (AFUE)	Gas Furnace (AFUE)	Gas Wall Furnace (AFUE)	Oil Boiler (AFUE)	Oil Furnace (AFUE)	Propane Furnace (AFUE)
1970	98	5.5	70	60	50	72	70	60
1972	98	6.21	72.3	62.7	59.5	75.2	73.6	62.7
1973	98	6.21	72.3	62.7	59.5	75.2	73.6	62.7
1974	98	6.21	72.3	62.7	59.5	75.2	73.6	62.7
1975	98	6.21	72.3	65.825	59.5	75.2	73.6	65.825
1976	98	6.87	72.3	66.12133333	59.5	75.2	74.1	66.12
1977	98	6.89	72.3	66.41766667	59.5	75.2	74.5	66.42
1978	98	7.24	72.3	66.714	59.5	75.2	75	66.71
1979	98	7.34	72.3	68.6565	59.5	75.2	75.5	68.66
1980	98	7.51	72.3	70.599	59.5	75.2	76	70.60
1981	98	7.7	77.4	70.441	63.1	77.4	76.8	70.44
1982	98	7.79	77.4	70.283	63.1	77.4	77.5	70.28
1983	98	8.23	77.4	70.125	63.1	77.4	78.3	70.13
1984	98	8.45	77.4	72.61795	63.1	77.4	78.6	72.62
1985	98	8.56	77.4	72.8865	63.1	77.4	78.6	72.89
1986	98	8.7	78.2	73.7325	64.2	81.6	79.6	73.73
1987	98	8.93	78.2	74.3305	64.2	81.6	79.8	74.33
1988	98	9.13	78.2	74.86195	64.2	81.6	80.4	74.86
1989	98	9.26	79.7	74.673	65.6	83.1	80.4	74.67
1990	98	9.46	79.7	76.70038	65.6	83.1	80.3	76.70
1991	98	9.77	79.7	77.53506	65.6	83.1	80.8	77.54
1992	98	10.6	79.7	82.075255	65.6	83.1	80.8	82.08
1993	98	10.86	79.7	82.40836	65.6	83.1	80.9	82.41
1994	98	10.94	79.7	82.433065	65.6	83.1	80.9	82.43
1995	98	10.97	79.7	82.33027	65.6	83.1	80.9	82.33
1996	98	11	79.7	82.65663	65.6	83.1	80.9	82.663
1997	98	10.97	79.7	82.86116	65.6	83.1	80.9	82.86
1998	98	11.29	79.7	82.61708	65.6	83.1	80.9	82.62
1999	98	11.29	79.7	82.63403	65.6	83.1	80.9	82.62
2000	98	11.21	79.7	82.620087	65.6	83.1	80.9	82.62
2001	98	11.3	79.7	83.15	65.6	83.1	80.9	82.62
2002	98	11.31	79.7	83.15	65.6	83.1	80.9	82.62
2003	98	11.31	79.7	83.15	65.6	83.1	80.9	82.62

Source: GAMA 2002, GAMA 2003
Note: Furnace fan efficiencies are handled in the heating and cooling model, and are documented in the companion report (Warner 2005).
Cells with yellow shading have data extended from previous data point.

3.1.3.2 Cooling Equipment Efficiencies

The cooling efficiency for Central Air Conditioners and Electric Heat Pumps are rated by the seasonal efficiency of the equipment or SEER. Room Air Conditioners are rated by EER or Energy Efficiency Ratio, the ratio of the cooling output (in BTU) divided by the electrical energy consumption (in watt-hours).

Table 5. Shipment Weighted Efficiencies for Cooling Equipment

Year	Central Air Conditioner (SEER)	Electric Heat Pump (SEER)	Room Air Conditioner (EER)
1970	6.5	5.5	5.8
1972	6.66	6.21	5.98
1973	6.75	6.21	6
1974	6.85	6.21	6.1
1975	6.97	6.21	6.2
1976	7.03	6.87	6.4
1977	7.13	6.89	6.55
1978	7.34	7.24	6.72
1979	7.47	7.34	6.87
1980	7.55	7.51	7.02
1981	7.78	7.7	7.06
1982	8.31	7.79	7.14
1983	8.43	8.23	7.29
1984	8.66	8.45	7.48
1985	8.82	8.56	7.7
1986	8.87	8.7	7.8
1987	8.97	8.93	8.06
1988	9.11	9.13	8.23
1989	9.25	9.26	8.48
1990	9.31	9.46	8.73
1991	9.49	9.77	8.8
1992	10.46	10.6	8.88
1993	10.56	10.86	9.05
1994	10.61	10.94	8.97
1995	10.68	10.97	9.03
1996	10.68	11	9.08
1997	10.66	10.97	9.09
1998	10.92	11.29	9.08
1999	10.96	11.29	9.07
2000	10.95	11.21	9.3
2001	11.07	11.3	9.63
2002	11.07	11.31	9.75
2003	11.07	11.31	9.75

Values remain at 2003 levels for subsequent years. Cells with yellow shading contain data from previous year.
Sources: Central Air Conditioner and Electric Heat Pump (ARI 2003), Room Air Conditioner (AHAM 2003).

3.1.3.3 Room Air Conditioner Consumption

Room air conditioners tend to be operated not by central thermostatic control, but rather in a manual mode where the room occupant turns the air conditioner on and off depending on room temperature and occupancy. These complex operating patterns are difficult to model with thermal simulation models such as DOE-2. For this reason, we chose to use a simpler method for estimating room air conditioner energy consumption, based on the AHAM (Association of Home Appliance Manufacturers) test procedure. This method is summarized in Equation 1.

$$UEC = \frac{days \times \frac{hours}{day} \times capacity}{EER} \qquad \textbf{Equation 1}$$

Where

UEC	=	Unit energy consumption (kWh/year)
days	=	Average annual days of room air conditioner operation (days/year)
hours/day	=	Average daily hours of room air conditioner operation (hours/day)
capacity	=	Rated capacity of the room air conditioner (Btu/hour)
EER	=	Energy-efficiency ratio (Btu/kWh)

Because cooling loads and usage vary with climate, we estimate a default *days* and *hours/day* value for each of the cities for which we had weather data (Appendix C-1). We estimate the default daily operating hours using equation 2. These values are rounded to the nearest integer. Climate data used in this equation are drawn from the typical meteorological year (TMY2) weather tapes (Marion and Urban 1995). The first term in equation 2 accounts for the severity of the climate, in terms of dry bulb temperature, while the second term accounts for how humid the climate is. Note that the humidity term is assumed to equal zero for locations above 40°N latitude. The parameters in equation 2 were estimated heuristically so as to yield results that looked reasonable across a range of climates.

$$hours = \frac{2}{5} \times (\mathrm{temp}_{db} - 80) + 20 \times (1.5 - \frac{\mathrm{temp}_{db}}{\mathrm{temp}_{wb}}) \qquad \textbf{Equation 2}$$

Where

temp_{db}	=	Drybulb temperature at cooling design-day conditions (°F)
temp_{wb}	=	Wetbulb temperature at cooling design-day conditions (°F)

We then derive a value for annual RAC compressor hours from the AHAM test procedure manual (AHAM 1982). We used the value corresponding to 66% of full-load, to account for some cycling that occurs in normal room air conditioner operation (These values are shown in Appendix C-1. Where one of our weather cities was not listed in the AHAM document, the Cooling Load Hour value shown in Appendix C-1 is extrapolated from the geographically closest city, using the TMY2 cooling-degree hours at 74° F as a scaling factor.

Finally, the average days per year of operation is simply the ratio of annual compressor hours to the average daily hours of operation.

Room air conditioner capacity is either input by the user or a national-average typical value is used (12,000 Btu/hour). EER is also either user-entered or drawn from the shipment-weighted average for the year in which the air conditioner was sold (as specified by the user).

3.1.4 Thermostats and Thermostat Schedules

The Home Energy Saver is capable of modeling both standard and programmable thermostats. The default thermostat assigned to a new session is a standard thermostat with the default schedule and temperature settings outlined in Table 6. Users can adjust the temperature and time schedules for the two periods (day and night), and can specify a separate schedule for weekdays and weekends/holidays.

Table 6. Default Thermostat Schedule for Standard Thermostats

		Temperature (˚F)	
	Hour	Heating	Cooling
Day	8:00 AM	68	78
Night	5:00 PM	64	81

Alternatively, users can choose a programmable thermostat, which defaults to the schedule outlined in Table 7. As with a standard thermostat, users can specify alternate times and temperatures for the four periods, to differentiate between weekday and weekend/holiday schedules.

Table 7. Default Thermostat Schedule for Programmable Thermostats

		Temperature (˚F)	
	Hour	Heating	Cooling
Wake	7:00 AM	64	78
Leave	9:00 AM	64	78
Evening	7:00 PM	68	81
Sleep	11:00 PM	68	81

The thermostat schedule is sent as an input to the DOE-2 calculation engine where it is used in calculating energy consumption by the heating and cooling equipment.

3.1.5 Internal Gains

Anything producing heat as a waste product affects the heating and cooling loads within the house. The waste heat causes an increase in the cooling energy consumption, and a decrease in the heating energy consumption. The Home Energy Saver accounts for internal gains by passing information about internal heat loads to the DOE-2 building simulation engine. Information about the number of occupants and the energy consumption for lighting and appliances, including water heater (when located in conditioned space), for all equipment located within the conditioned space is sent as internal gains to DOE-2. This value also reflects waste heat from gas appliances located within the conditioned space.

3.1.6 Thermal Distribution Efficiency

As documented in a companion report (Warner 2005), the Home Energy Saver uses the hourly DOE-2 thermal simulation model to estimate heating and cooling consumption. The treatment of air distribution duct losses in DOE-2 is very simple, allowing only a single value of duct losses (expressed as a percent of air input to the ducts) that applies to every hour throughout the year.

Although it would be desirable to model duct efficiency as varying throughout the year, as a function of the ducts' environmental conditions, this would require a significant effort in modifying DOE-2.

Instead, we use an annual-average method for estimating the effect of duct materials and the type of space in which the majority of their duct system is located, since duct losses differ significantly depending on these factors. We used the ASHRAE 152P duct model to estimate duct losses for use as an input to DOE-2 (ASHRAE 1997a). Although this model is intended to calculate seasonal duct efficiencies based on detailed diagnostic testing, we assumed typical values for most of the inputs (such as duct surface area and number of return ducts) so that the number of inputs required of the user is more reasonable.

Users are able to specify whether or not the ducts are insulated and/or sealed, and the duct location. Insulated ducts are assumed to have R-5 insulation, while uninsulated ducts are assigned an insulation value of R-1 (to account for the thermal resistance of the external air film on the ducts). Unsealed ducts are assumed to have a leakage of 30% of the total air handler flow, based on field testing in existing California homes (Jump et al. 1996). Because concerted duct sealing efforts can typically reduce leakage by one-half, we assume that sealed ducts have a leakage rate of 15%. If users choose not to specify their duct location, we infer the location based on the type of foundation and typical building practices. Table 8 shows the default duct location that corresponds to each of the foundation types available in HES.

Table 8. Default Duct Location

Foundation Type	Assumed Duct Location
Unconditioned Basement	Unconditioned Basement
Conditioned Basement	Conditioned Space
Ventilated Crawlspace	Ventilated Crawlspace
Unventilated Crawlspace	Unconditioned Basement
Slab-on-grade	Unconditioned Attic

To account for the effect of local climate on ducts located in unconditioned spaces, the ASHRAE 152P model uses design-day weather data from the ASHRAE Handbook of Fundamentals (ASHRAE 1997b). The model inputs are the winter 97.5% design dry-bulb and the summer 2.5% design dry-bulb, shown in Table C-1.

The ASHRAE 152P model generates seasonal duct efficiencies for both the heating and cooling seasons, which are then averaged together using weights corresponding to the HDD and CDD in that location, normalized to the national average degree-days (using TMY2 data). These weighting factors are shown in Appendix C-1, in the "duct factor" columns. A single annual average duct efficiency is passed to the DOE-2 model as an input to the hourly thermal simulation. This annual duct efficiency is determined based on the type of heating and cooling equipment in the house. The logic for determining the annual duct efficiency is captured in Table

2 by the intersection of heating columns and cooling rows based on the presence or absence of ducts for each type of equipment.

Table 9. Annual Duct Efficiency Based on HVAC equipment

Cooling Equipment	Heating Equipment	Duct Efficiency
Doesn't Have Ducts	Doesn't Have Ducts	100% (no duct losses)
Doesn't Have Ducts	Has Ducts	HSE
Has Ducts	Doesn't Have Ducts	CSE
Has Ducts	Has Ducts	$efficiency_{ducts} = DF * HSE + (1 - DF) * CSE$

Notes:

DF = Weight factor based on relative proportions of heating- and cooling-degree days for location
HSE = Weighted heating seasonal duct efficiency from ASHRAE 152P model
CSE = Weighted cooling season duct efficiency from ASHRAE 152P model

3.1.6.1 Boiler Pipe Efficiency

Boiler pipes are assumed to have a baseline efficiency of 90% (Wenzel 1997). Users are able to indicate whether their pipes are insulated. For insulated pipes we stipulate a 5% increase in efficiency.

3.1.7 Infiltration

Air infiltration can be a significant component of thermal losses in residential buildings. In the Home Energy Saver, we calculate the energy impact of air infiltration in the DOE-2 simulation model, based on the leakage area of the thermal shell and location-specific weather data. Although leakage area can be measured using diagnostic testing, few homeowners know the leakage area of their home. To compensate for this lack of information, we estimate leakage area using a database of measured leakage values compiled by LBNL. This database has been analyzed to provide average leakage values for single-family homes based on a few key parameters that strongly influence air leakage (Sherman and Matson 1997, Matson 1998). The LBNL leakage database reports leakage values as Normalized Leakage (NL), or square feet of leakage area per 1000 square feet of conditioned floor area. For input to DOE-2, we converted these normalized leakage values to fractional leakage areas (FLA) using equation 3.

$$FLA = \frac{NL/1000}{\left(\frac{8 \times 0.3048 \times stories}{2.5}\right)^{0.3}}$$ **Equation 3**

where
FLA = Fractional leakage area, the ratio of envelope leakage area to floor area (square feet/square feet)
NL = Normalized leakage (sq. ft. leakage/sq. ft. conditioned floor area)
stories = 1 if single-story house, otherwise stories = 2
8 = Assumed ceiling height (feet) for the house
0.3048 = conversion factor feet to meters
Source: Sherman, et. al. 1997

The key parameters used to select a house's leakage value from the database are: house vintage (pre-1980, 1980 and later), stories (1, more than 1), shell condition (whether or not air leaks have been sealed in a comprehensive way), presence of a ducted heating or cooling system, and air leakage through the floor (slab or conditioned basement, vs. other foundation types). In addition, for houses built in 1990 or later, we assume a leakage value that is consistent with the "tight" thermal shells typically seen in new construction (NL = 0.5).

3.1.8 Combined Boilers

For houses where the main heating equipment also provides the hot water, the DOE-2 simulation engine calculates the hot water energy consumption. There are two different types of combined boiler, direct and indirect. Direct combined boilers heat the water upon demand. Indirect combined boilers have a storage tank, similar to a stand-alone hot water heater, which provides hot water upon demand. The boiler maintains a steady temperature within the hot water storage tank.

3.1.9 DOE-2 Post-processing

When the DOE-2.1E simulation program executes, it produces a large text output file containing a series of user-specified output reports. We then post-process the raw DOE-2 output file to extract only those results that will be presented to the HES user. These results are drawn from the BEPS, SV-A, SS-A, and PV-A standard reports offered by DOE-2 (Winkelmann, et. al. 1993). Table 10 shows which values are drawn from these reports. The post-processor is implemented in the Perl scripting language.

Table 10. DOE-2.1E Output Reports Used in HES

DOE-2 report	Values used in reporting to user	Units
BEPS	Space heat (all fuels) Space cool Pumps & miscellaneous Supplemental heat (heat pump strip heat) Vent fans	Mbtu
SV-A	Heating equipment capacity Cooling equipment capacity	kBtu/hour
SS-A	Annual heating load Annual cooling load Peak heating load Peak cooling load	Mbtu Mbtu kBtu/hour kBtu/hour
PV-A	Boiler capacity	KBtu/hour

3.2 Water Heater Energy Consumption

Two main types of water heaters are modeled in the Home Energy Saver, separate "stand-alone" units, and cases where the home's heating system (boiler) provides the domestic hot water supply. When the hot water is supplied by from a boiler, water heating energy is calculated in the DOE-2 building simulation model. All other water heaters are modeled according to the methodology outlined in this section of the report. For homes with a clothes washer and/or dishwasher, the required gallons of hot water per day is provided as an input to the hot water model (described below) by the clothes washer and dishwasher models.

This module calculates energy consumption for heating water in three steps[5]. The first step is to estimate average daily hot water use. This calculation is based on number and ages of people living in the house, presence or absence of a dishwasher and a clothes washer, the water heater temperature setting and tank size, and the local climate (Lutz, et al, 1996).

Once the average daily hot water use has been estimated, a simple calculation is performed to determine the daily energy use by the water heater. The calculation uses the energy consumption characteristics of the water heater as determined by the DOE Energy Factor test, ambient air and inlet water temperatures, and how much hot water is used on an average day. The last step is to convert the daily energy use into annual consumption of specific fuels.

3.2.1 Daily Hot Water Use

The Home Energy Saver web site uses the following equation[6] to estimate average daily hot water use in gallons per day (Lutz, et al. 1996). This equation was modified and improved from Lutz et al's version by subtracting out the constant assumed hot water use of clothes washers and dishwashers (the variables *cloth* and *dish* in Equation 4), and adding two variables (*cwGals* and *dwGals*) that allow users to individually specify their clothes washer and dishwasher hot water use (e.g. specifying loads washed at certain temperatures). These two variables (*cwGals* and *dwGals*) are used to allocate the water heater energy consumption into three portions; clothes washer, dishwasher and other. The energy consumed by the water heater for the clothes washer and dishwasher portions is reported with the Major Appliance energy in the final report. The calculation of hot water use by clothes washers and dishwashers is described elsewhere in this report.

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[5] Methodology for water heating provided by combined space and water heating systems is described in the companion report (Warner 2005).

[6] The original development of the water heating analytical method was sponsored by the U.S. Department of Energy, Office of Building Technology, State, and Community Programs as part of their appliance standards analysis program (US DOE 2000c).

$$Use_{wh} = \begin{bmatrix} -1.78 + 0.9744 \times occupants + 6.3933 \times age1 \\ +10.5178 \times age2 + 15.3052 \times (age3 + age4) \\ -0.1277 \times T_{tank} + 0.1437 \times tank\_size \\ -0.1794 \times T_{in} + 0.5115 \times average\_temp \\ +10.2191 \times adult\_at\_home - dish - cloth \\ +cwGals + dwGals \end{bmatrix} \times senior \times pay \qquad \textbf{Equation 4}$$

where

Use_{wh} = hot water consumption (gallons/day)
occupants = number of persons in household (sum age1-4)
age1 = number of people aged 0-5 yrs
age2 = number of people aged 6-13 yrs
age3 = number of people aged 14-64 yrs
age4 = number of people aged 65- yrs
T_{tank}= water heater thermostat setpoint (°F)
tank_size = rated volume of water heater (gallons)
T_{in} = inlet water temperature (°F)
average_temp = average annual outdoor air temperature (°F)
adult_at_home = 1 if TRUE, 0 if FALSE, adult at home during day
dish = dishwasher hot water use embedded in original Lutz et al. equation (Lutz, et al. 1996, Equation 12)
cloth = clothes washer hot water use embedded in original Lutz et al. equation (Lutz, et al. 1996, Equation 8)
cwGals = calculated gallons of hot water used by clothes washer based on user inputs, see Section 3.3.3 [replaces more generic estimation method (cloth)] (gallons/day)
dwGals = calculated gallons of hot water used by dishwasher based on user inputs, see Section 3.3.4 [replaces more generic estimation method (dish)] (gallons/day)
pay = 1.3625 if residents do not pay for energy to make hot water (to reflect less water-conserving behavior), otherwise pay = 1
senior = 0.379 if only seniors live in household and it is a multifamily residence, otherwise senior = 1

3.2.2 Daily Water Heater Energy Use

To estimate average daily hot water thermal-energy consumption, we use the following equation (Lutz, et al., 1996). T_{in} is calculated based on the weather data for the weather station to which the house was assigned, described more fully in Section 3.1.1 Climate Modeling.

$$Q_{in} = \frac{use_{wh} \times dens \times Cp \times (T_{tank} - T_{in})}{RE} \times \left[1 - \frac{UA \times (T_{tank} - T_{amb})}{Pon}\right] + 24 \times UA \times (T_{tank} - T_{tamb}) \qquad \textbf{Equation 5}$$

where

Q_{in} = water heating energy consumption (MBtu/day)

use_{wh} = hot water use per day (gallons) from Equation 4
dens = density of water (8.293752 lb/gal)
Cp = specific heat of water (1.000743 Btu/lb-°F)
T_{tank}= water heater thermostat setpoint (°F)
T_{in} = inlet water temperature (°F)
RE = recovery efficiency of water heater
UA = standby heat loss coefficient of water heater (Btu/hr-°F) from Eq. 6
T_{amb} = annual average air temperature around water heater (°F)
Pon = rated input power of water heater (Btu/hr)

3.2.3 Ambient Air Temperature

The average annual air temperature around the water heater (T_{am}) is derived from the location of the water heater. If the water heater is located inside conditioned space, T_{am} is set to the indoor air temperature (default value of 67.5 °F). A future improvement of the modeling would be to have this default indoor air temperature correspond to thermostat settings. If the water heater is located in the basement, T_{am} is set to the average of the indoor and outdoor air temperatures (outdoor air temperature taken from the 30-year-average weather tape data for their location, see Section 4.1 Weather Data), otherwise T_{am} is set to the average outdoor air temperature.

3.2.4 Standby Heat Loss Coefficient

To calculate the standby heat loss coefficient, we use the equation for heat loss from the DOE Energy Factor test procedure for water heaters, (US DOE 1993) as shown in Equation 6.

$$UA = \frac{\frac{1}{EF} - \frac{1}{RE}}{67.5 \times \left(\frac{24}{Q_{out}} - \frac{1}{RE \times Pon} \right)} \qquad \textbf{Equation 6}$$

where

UA = standby heat loss coefficient (Btu/hr-°F)
EF = Energy factor of water heater
RE = recovery efficiency of water heater
Pon = rated input power of water heater (Btu/hr)
Q_{out} = Energy content of water drawn from water heater during 24 hour test (41093.7 Btu/day)

3.2.5 Annual Water Heater Energy Use

To estimate average annual hot water energy consumption by type of fuel, we use the following equation.

$$EC_f = 365 \times \frac{Q_{in}}{FC} \qquad \textbf{Equation 7}$$

where

EC_f = annual energy consumption for fuel f
Qin = daily water heater thermal-energy use

FC = heat content for fuel f, from Table 3
365 = number of days per year

3.2.6 User Inputs to the Water Heater Model

At the simple inputs level of the Home Energy Saver, users are asked to select the fuel of their water heater. The water heater characteristics (tank size, year purchased, etc.) are defaulted based on choice of water heater fuel (Table XX). The values for recovery efficiency and rated input for the water heater are derived from manufacturers' product specifications (GAMA 1996) for typical models of each fuel type. Tank size was taken from Table 4.4 of the *Energy Data Sourcebook* (Wenzel 1997).

Table 11. Default Water Heater Characteristics by Fuel

Water Heater Fuel	Year Purchased	Recovery Efficiency (%)	Rated Input		Tank Size (gal)
			Value	Units	
Electricity	1986	0.98	4.5	kWh/hr	50
Natural Gas	1986	0.76	38,000	Btu/hr	40
LPG	1986	0.76	38,000	Btu/hr	40
Fuel Oil	1986	0.76	0.65	gal/hr	32

3.2.7 Water Heater Energy Factor

The energy factor for the water heater is a derived shipment-weighted efficiency based on the year the equipment was purchased (Table 12). This number is the average efficiency for all units sold within a particular year weighted by the number of units in each efficiency bin (GAMA 1996). For LPG-fired water heaters, we assumed the same energy factor as for natural gas-fire units. For fuel oil-fired units, we assumed an energy factor of 0.54 before 1990 and 0.59 after 1990 (Lutz, personal communication).

Table 12. Shipment Weighted Energy Factors for Water Heaters

Year	Electric	Natural Gas	LPG	Fuel Oil
1972	0.798	0.474	0.474	0.54
1973	0.798	0.474	0.474	0.54
1974	0.798	0.474	0.474	0.54
1975	0.798	0.474	0.474	0.54
1976	0.799	0.475	0.475	0.54
1977	0.799	0.475	0.475	0.54
1978	0.8	0.476	0.476	0.54
1979	0.801	0.476	0.476	0.54
1980	0.802	0.477	0.477	0.54
1981	0.803	0.478	0.478	0.54
1982	0.804	0.479	0.479	0.54
1983	0.806	0.48	0.48	0.54
1984	0.809	0.481	0.481	0.54
1985	0.812	0.483	0.483	0.54
1986	0.815	0.484	0.484	0.54
1987	0.819	0.486	0.486	0.54
1988	0.823	0.488	0.488	0.54
1989	0.828	0.49	0.49	0.54
1990	0.832	0.492	0.492	0.59
1991	0.837	0.494	0.494	0.59
1992	0.842	0.496	0.496	0.59
1993	0.846	0.498	0.498	0.59
1994	0.85	0.499	0.499	0.59
1995	0.854	0.5	0.5	0.59
1996	0.857	0.501	0.501	0.59
1997	0.857	0.501	0.501	0.59
1998	0.857	0.501	0.501	0.59
1999	0.857	0.501	0.501	0.59
2000	0.857	0.501	0.501	0.59
2001	0.857	0.501	0.501	0.59
2002	0.857	0.501	0.501	0.59
2003	0.857	0.501	0.501	0.59
2004	0.9	0.55	0.55	0.59
2005	0.9	0.55	0.55	0.59

Energy Factor for Water Heaters is percentage efficiency divided by 100.
Source: GAMA Directory.
Note: yellow cells contain data held constant from previous real data point.
In 2004, a new standard for water heaters went into effect (green cells).

3.2.8 User Inputs for Water Heater Analysis

In the detail screens of the Home Energy Saver, users can modify the water heater characteristics to more closely simulate their equipment and it’s usage. Table 13 shows the range of values for the inputs previously mentioned and lists other characteristics (and their range of values) that users can modify.

Table 13. User Inputs for Water Heaters (Detailed Inputs Level)

Variable Name	Range of Possible Values	Default Value	Modeling Treatment
Fuel	Electric Natural Gas Liquid Propane Gas (LPG) Fuel Oil	Varies by region (zip code)	
Type	Separate from heating system	Separate	Water heater energy calculated using process described in this section
	Combined boiler, tankless		Water heating energy calculated by DOE-2
	Combined boiler, storage tank		
Pay for Fuel (No if solar)	Yes No	Yes	
Adult at Home during weekdays	Yes No	No	
Energy Factor	0 – 1.0	See Table 12	
Recovery Efficiency	0 – 1.0	See Table 11	
Rated Input	0 – 99,000 (kWh, Btu/hr)	See Table 11	
Tank Size (gallons)	0 – 500	See Table 11	
Thermostat setting	Low (120 °F) Medium-Low (130 °F) Medium (140 °F) Medium-High (150 °F) High (160 °F)	Medium-Low (130 °F)	
Location	Basement or Crawlspace	Varies by foundation type	T_{amb}=average($T_{indoors}$+$T_{outdoors}$)
	Garage		T_{amb}= $T_{outdoors}$
	Indoors		T_{amb}= $T_{indoors}$; standby losses sent to DOE2 as internal gains
	Outdoors		T_{amb}= $T_{outdoors}$

Note: T_{amb} = annual average air temperature around water heater (°F)
$T_{indoors}$ = 67.5 ˚F
$T_{outdoors}$ = average outdoor air temperature from weather tape data

3.3 Major Appliances

Refrigerators, freezers, clothes washers, clothes dryers, dishwashers, stoves and ovens are included in the “Major Appliance” category. Using the number and approximate age of major appliances, the model estimates energy consumption, based on historic sales-weighted efficiency data. This section contains the energy estimation methodology for each appliance. The estimated consumption across equipment types is summed to arrive at the “Major Appliance” category totals.

3.3.1 Refrigerator Energy Consumption

Refrigerators can have very different energy consumption depending on the year of manufacture and features that affect energy use such as size, automatic defrost, or side-by-side design. To estimate the energy consumption of these appliances, we use the calculation method described in the *Energy Data Sourcebook* (Wenzel et al. 1997). Due to changes in technology and Federal efficiency standards, refrigerators have become significantly more efficient over time. Because most consumers do not know the Energy Factor of their refrigerator(s), we use a shipment-weighted energy factor based on the year the refrigerator was purchased (Table 14). This number is the average energy factor for all units sold within a particular year weighted by the number of units in each efficiency bin (AHAM 1996). Note that for purposes of this model, all refrigerators are assumed to be combined refrigerator/freezers. We do not distinguish between refrigerator/freezers located in conditioned space vs. those located in unconditioned space (e.g. in the garage).

$$EC = \frac{(365 \times AV)}{EF} \qquad \textbf{Equation 8}$$

where

EC = Annual energy consumption (kWh/year)
AV = Adjusted volume (cubic feet)
EF = Energy Factor (kWh/cubic feet•year)

The refrigerator / freezer adjusted volume is intended to capture in a single parameter the relatively high energy intensity of the refrigerator's frozen food compartment compared to the fresh food compartment. Equation 9 is used to calculate adjusted volume (US DOE 1995), and corresponds to the definition used in specification of federal minimum efficiency standards.

$$AV = size \times \left(frac + (1 - frac) \times 1.63 \right) \qquad \textbf{Equation 9}$$

where

AV = Adjusted volume (cubic feet)
size = "Nominal" refrigerator/freezer volume (cubic feet)
frac = Fraction of refrigerator volume devoted to fresh-food storage ($0 \le frac \le 1$)

For side-by-side refrigerators, a fresh-food fraction of 0.6 is used, while all other configurations use a fraction of 0.66. Note that this model does not account for refrigerator usage factors that might vary among units, such as refrigerator and freezer temperature settings, door opening frequency, food loading rates, and ambient temperatures. While these factors can have a large impact on energy consumption, their effect has not been quantified in a way that could be incorporated into a parametric model such as this.

3.3.1.1 User Inputs to the Refrigerator Model

At the simple inputs level, users can specify the number of refrigerators in their house, from zero to three refrigerators. Each refrigerator specified has default characteristics (appliance type, size and year) assigned depending on whether it is the first, second or third refrigerator in the house (Table 8). In the detailed inputs calculation mode, users can alter these default characteristics.

Table 14. Shipment Weighted Energy Factors for Refrigerators

Year	General	Automatic defrost		Manual Defrost
		Side-by-Side	Top Freezer	
1972	3.84	3.57	3.56	6.69
1973	4.03	3.81	3.81	6.77
1974	4.22	4.05	4.06	6.85
1975	4.41	4.29	4.31	6.93
1976	4.6	4.53	4.56	7.01
1977	4.79	4.77	4.81	7.09
1978	4.96	5.02	4.75	7.18
1979	5.27	5.32	5.21	7.25
1980	5.59	5.62	5.67	7.32
1981	6.09	5.93	6.12	7.39
1982	6.12	6.02	6.3	7.69
1983	6.39	6.1	6.47	7.98
1984	6.57	6.12	6.75	8.19
1985	6.72	6.36	6.89	5.85
1986	6.83	6.49	6.95	6.14
1987	7.45	7.28	7.66	5.45
1988	7.6	7.45	7.83	5.09
1989	7.78	7.68	8.06	4.55
1990	8.15	7.78	8.51	4.84
1991	8.44	8.26	8.91	4.32
1992	8.8	8.69	9.36	3.5
1993	11.13	12.18	11.39	3.89
1994	11.19	12.45	11.37	4.13
1995	11.22	12.41	11.47	3.75
1996	11.22	12.08	11.48	4.21
1997	10.63	11.44	10.88	3.99
1998	10.50	11.30	10.74	3.94
1999	10.40	11.20	10.64	3.90
2000	11.11	11.96	11.37	4.17
2001	13.58	14.62	13.89	5.10
2002	15.17	16.33	15.52	5.69
2003	15.30	16.47	15.65	5.74

Notes on Refrigerator Energy Factors:
1. Energy Factor has units of (kWh/cubic feet_year), where cubic feet is adjusted volume.
2. Source: (AHAM 1996) (AHAM 2003) - AHAM changed the reporting of refrigerator efficiencies after 1996. Annual data is available for the "General" category. Data for the other refrigerator types for years subsequent to 1996 was

derived from the “General” refrigerator efficiency by scaling the efficiency for a particular type of refrigerator proportional to the annual change in efficiencies in the “General” refrigerator category.
3. Data has been held at 2003 levels for subsequent years.

Table 15. User Inputs for Refrigerator Analysis

Variable Name	Range of possible Values	Default Value	unit
Type	General Automatic Defrost, Side-by-Side Automatic Defrost, Top Freezer Manual Defrost	General	
Year	1972-2002	1990 (1st unit) 1983 (2nd unit) 1972 (3rd unit)	year
Size	Small (13-15 cu ft) Medium (16-18 cu ft) Large (19-21 cu ft) Extra-Large (22+ cu ft)	20 (1st unit) 17 (2nd unit) 14 (3rd unit)	cu. feet

1 Users can specify zero to three refrigerators at the "simple inputs" calculation level.
2. For calculating adjusted volume, the mid-range of each size bin is used, with the exception of the “Extra-Large” bin which uses 24 cu. ft as the calculation value.

3.3.2 Freezer Energy Consumption

Freezer energy consumption is driven by many factors such as configuration (e.g. upright freezers versus chest freezers) and technology (automatic vs. manual defrost capability). Additionally, over the years, freezers have increased in size, causing the overall energy consumption to increase. To estimate the energy consumption of these appliances, we use the calculation method described in the *Energy Data Sourcebook* (Wenzel et al. 1997). Because most consumers do not know the Energy Factor of their freezer(s), we use a shipment-weighted energy factor based on the year the freezer was purchased (Table 16). This number is the average energy factor for all units sold within a particular year weighted by the number of units in each efficiency bin (AHAM 1996). Note that for purposes of this model, all freezers are assumed to be stand-alone units (no fresh food compartment).

$$EC = \frac{(365 \times AV)}{EF} \qquad \textbf{Equation 10}$$

where

EC = Annual energy consumption (kWh/year)
AV = Adjusted volume (cubic feet)
EF = Energy Factor (kWh/cubic feet•year)

The adjusted volume is intended to capture in a single parameter the relatively high energy intensity of the freezer's frozen food compartments. Equation 11 is used to calculate adjusted volume (US DOE 1995). This definition corresponds to the volume used in defining federal minimum efficiency standards

$$AV = size \times 1.73 \qquad \textbf{Equation 11}$$

where

AV = Adjusted volume (cubic feet)
Size = "Nominal" freezer volume (cubic feet)

Note that this model does not account for freezer usage factors that might vary between units, such as temperature settings, door opening frequency, food loading rates, and ambient temperatures. While these factors can have a large impact on energy consumption, their effect has not been quantified in a way that could be incorporated into a parametric model such as this.

3.3.2.1 User Inputs to the Freezer Model

In the simple inputs level, users can specify the number of freezers in their house, from zero to two units. Each freezer specified has default characteristics (appliance type, size and year) assigned depending on whether it is the first or second freezer in the house (Table 17). In the detailed inputs level, users can alter these default characteristics.

Table 16. Shipment Weighted Energy Factors for Freezers

Year	General	Upright Design		Chest Freezers
		Automatic Defrost	Manual Defrost	
1972	7.29	5.23	7.65	8.78
1973	7.72	5.43	7.93	9.27
1974	8.15	5.63	8.21	9.76
1975	8.58	5.83	8.49	10.25
1976	9.01	6.03	8.76	10.74
1977	9.44	6.23	9.03	11.23
1978	9.92	6.41	9.31	11.74
1979	10.39	6.95	9.84	11.77
1980	10.85	7.49	10.37	11.8
1981	11.13	8.03	10.89	11.82
1982	11.28	8.23	11.38	11.87
1983	11.36	8.43	11.44	11.91
1984	11.6	8.58	11.51	12.31
1985	11.55	9.5	11.56	12.04
1986	12.07	9.44	12.07	12.84
1987	12.93	9.57	12.6	14.41
1988	12.91	9.31	12.61	14.46
1989	13.89	9.47	13.86	15.48
1990	14.19	10.41	14.15	15.67
1991	14.17	10.43	13.95	15.92
1992	13.95	10.38	13.73	15.63
1993	17.38	13.65	17.3	19.43
1994	16.91	13.14	17.02	18.89
1995	16.57	13.16	16.95	18.28
1996	16.56	13.11	17.09	18.18
1997	16.41	12.99	16.94	18.02
1998	16.3	12.90	16.82	17.89
1999	16.16	12.79	16.68	17.74
2000	15.93	12.61	16.44	17.49
2001	17.38	13.76	17.94	19.08
2002	17.83	14.12	18.40	19.57
2003	17.06	13.51	17.61	18.73

Notes on Freezer Energy Factors:
1. Energy Factor has units of (kWh/cubic feet_year), where cubic feet is adjusted volume.
2. Source: (AHAM 1996) (AHAM 2003) - AHAM changed the reporting of freezer efficiencies after 1996. Annual data is available for the “General” category. Data for the other freezer types for years subsequent to 1996 was derived from the “General” freezer efficiency by scaling the efficiency for a particular type of freezer proportional to the annual change in efficiencies in the “General” freezer category.
3. Data has been held at 2003 levels for subsequent years.

Table 17. User Inputs to the Freezer Analysis

Variable Name	Range of possible Values	Default Value	unit
Type	General Upright, Automatic Defrost Upright, Manual Defrost Chest Freezer	General	
Year	1972-2004	1990 (1st unit) 1983 (2nd unit)	year
Size	Small (13-15 cu ft) Medium (16-18 cu ft) Large (19-21 cu ft) Extra-Large (22+ cu ft)	Medium (1st unit) Small (2nd unit)	cu. feet

3.3.3 Clothes Washer Energy Consumption

Although clothes washers consume energy for both mechanical activities and water heating energy, the majority of the energy used is for water heating. Both machine energy and water heating energy are directly dependent upon the number of loads washed. To estimate the energy consumption of these appliances, Equations 12 and 13 use the calculation method described in the Energy Data Sourcebook (Wenzel et al. 1997). Equation 14 calculates the water heating portion of the total clothes washer energy.

$$EC = ME + WE \qquad \textbf{Equation 12}$$

where

EC = Annual energy consumption in utility units
ME = Machine energy (kWh/year)
WE = Water heating energy attributable to clothes washer in utility units (returned from water heater module)

When ME and WE are in different units (e.g. for non-electric water heaters) the energy consumption for the clothes washer is calculated and stored separately for both fuels (e.g. 126 kWh and 23 therms).

3.3.3.1 Calculating Machine Energy

The machine energy is the electrical energy consumed by all the physical processes necessary to run a load of laundry (e.g. agitation, spin cycle), and is calculated using Equation 13.

$$ME = LE \times loads \times 52 \qquad \textbf{Equation 13}$$

where

LE = load energy (kWh/load)
loads = clothes washer loads/week
52 is weeks/year

Machine energy for the average new clothes washer has not changed significantly over time, so is assumed to be 0.27 kWh/load for the purposes of this model (DOE 1990, Page 3-22 table 3.17).

3.3.3.2 Calculating Water Heating Energy from Clothes Washer Use

The gallons of hot water used by the clothes washer is sent to the water heating model, which calculates the energy consumed by the water heater to supply this amount of hot water to the clothes washer. The daily usage (gallons) attributable to the clothes washer is calculated according to Equation 14 (Koomey et al. 1994).

$$use_{day} = \frac{(loads_{week} * use_{load})}{7} \qquad \textbf{Equation 14}$$

where

Use_{day} = hot water use (gallons/day),
$Loads_{week}$ = number of loads per week,
Use_{load} = hot water use for the average load (gallons/load)
7 = days per week

Energy consumed by the water heater in providing the necessary gallons of hot water for the clothes washer is calculated by the water heating model (see Section 3.2) and incorporated into Equation 12 to arrive at the total energy consumption for the clothes washer.

3.3.3.3 User Inputs to the Clothes Washer Model

At the simple inputs level in the Home Energy Saver, users only indicate whether or not a clothes washer is present in their house. A default value for the clothes washer contribution to gallons of hot water per day is set for those houses with clothes washer.

For the detailed inputs level, the number of clothes washer loads is assumed to be 380 loads/year (US DOE 1990) and gallons of hot water per load depends on the temperature setting for the load (Lutz et al. 1996). The default distribution of clothes washer temperature settings was based on our judgment about typical usage patterns. Users can customize the number of loads washed and the temperature settings to match the usage patterns in their house.

Table 18. Default Values for Calculating Clothes Washer Water Use

	Use_{day} (gallons/day)	# of $Loads_{week}$	Temperature (wash/rinse)	Use_{load} (gallons)	Source
Simple Level	8.2	-	-	-	(Koomey et al. 1994) Table 4
Detailed Inputs Level	9.1	2	Hot/Warm	32	(Lutz et al. 1996) Table 1
	0.0	0	Hot/Cold	20	"
	9.4	3	Warm/Warm	22	"
	2.9	2	Warm/Cold	10	"
total	21.4	7			"

3.3.4 Clothes Dryer Energy Consumption

Clothes dryers consume energy for both mechanical activities and the drying process. The majority of the energy used is for drying. Both machine energy and drying energy are directly dependent upon the number of loads dried. To estimate the energy consumption of these appliances, Equations 15 and 16 use the calculation method described by Wenzel et al. (1997).

$$EC_f = ME + DE \qquad \textbf{Equation 15}$$

where

EC_f = Annual energy consumption for fuel f
ME = Machine energy (kWh/year)
DE = Drying energy in utility units (kWh/year or therms/year)

Energy consumption is portrayed in "utility units" for each fuel type; the electric utility is kWh, natural gas utility unit is therms,

3.3.4.1 Machine Energy

The machine energy includes the energy consumed by all the mechanical and electrical processes necessary to dry a load of laundry (e.g. drum rotation, timers etc.). Equation 16 is used to calculate the machine energy.

$$ME = LE \times loads_{week} \times 52 \qquad \textbf{Equation 16}$$

where

LE = load energy (kWh)
$loads_{week}$ = clothes dryer loads/week
52 = weeks/year

Machine energy for the average new clothes dryer has not changed significantly over time, so is assumed to be 0.23 kWh/load for the purposes of this model (PG&E 1995).

3.3.4.2 Drying Energy

The energy consumed by the clothes dryer to produce heat necessary to dry the clothing is called the drying energy. The drying energy is calculated according to Equation 17.

$$DE = loads_{week} \times use_{load} \times 52 \qquad \textbf{Equation 17}$$

where

$Loads_{week}$ = number of loads per week,
Use_{load} = drying energy consumption per load (kWh or therms)
52 = weeks per year

The Home Energy Saver models electric and gas clothes dryers. Electric clothes dryers use 3.8 kWh and gas clothes dryers use 0.22 therms per load (PG&E 1995) for drying energy alone. This energy consumption is in addition to the electricity required to operate the mechanical functions of clothes drying (air circulation, drum rotation, timers and sensors, etc.) Our calculation process does not distinguish between models that have moisture-sensor termination and those that do not.

3.3.4.3 User Inputs to the Clothes Dryer Model

The method of estimating clothes dryer energy depends on the user inputs available for each of the different levels of user inputs. At the simple inputs level in the Home Energy Saver, no user inputs are available concerning the clothes dryer. An electric clothes dryer is assigned to the house as the default if users indicate that they have a clothes washer. The number of loads dried is assumed to be equal to the number of loads of laundry washed.

For the detailed inputs level of the Home Energy Saver, the initial number of clothes dryer loads is assumed to be 380 loads/year (US DOE 1990). Users can customize the number of loads dried and select the primary fuel used for providing heat.

3.3.5 Dishwasher Energy Consumption

Dishwashers consume energy for both mechanical functions and water heating, with the majority of the energy used for water heating. Both machine energy and water heating energy are directly dependent upon the number of loads washed. To estimate the energy consumption of these appliances, Equations 18 and 19 use the calculation method described by Wenzel et al. (1997).

$$EC = ME + WE \qquad \textbf{Equation 18}$$

where

EC = Annual energy consumption in utility units
ME = Machine energy (kWh/year)
WE = Water heating energy in utility units (returned from water heater)

When ME and WE are in different units (e.g. for non-electric water heaters) the energy consumption is reported and tracked in terms of more than one fuel (e.g. 126 kWh and 23 therms).

3.3.5.1 Machine Energy

The machine energy (Equation 19) includes the energy consumed by all the physical processes necessary to run a load of dishes (e.g. pumps, heating element for drying cycle).

$$ME = LE \times loads \times 52 \qquad \textbf{Equation 19}$$

where

LE = load energy (kWh/load)
loads = dishwasher loads/week
52 = weeks/year

Machine energy for dishwashers is assumed to be 0.78 kWh/load for the purposes of this model (US DOE 1990, Page 3-8 table 3.4).

3.3.5.2 Water Heating Energy

The quantity of hot water used by the dishwasher is sent to the water heating model, which calculates the energy consumed to supply this amount of hot water to the dishwasher. The daily hot water usage (gallons) attributable to the dishwasher is calculated according to Equation 20 (Koomey et al. 1994).

$$use_{day} = \frac{(loads_{week} * use_{load})}{7} \qquad \textbf{Equation 20}$$

where

Use_{day} = hot water use (gallons/day),
$Loads_{week}$ = number of loads per week,
Use_{load} = hot water user per average load (gallons/load)
7 = days per week

Energy consumed by the water heater in providing the necessary amount of hot water for the dishwasher is calculated by the water heating model (see Section 3.2) and incorporated into Equation 18 to arrive at the total energy consumption for the dishwasher.

3.3.5.3 User Inputs to the Dishwasher Models

At the simple inputs level, users are unable to indicate whether or not a dishwasher is present in their house. A dishwasher is assigned to the house if the user indicates that they own a clothes washer. The default value for the daily gallons of hot water used by the dishwasher is set at the time of dishwasher assignment.

For the detailed inputs level, the number of dishwasher loads is initially defaulted to 208 loads/year (US DOE 1990) with hot water usage of 11 gallons per load (Lutz et al. 1996). Users can indicate the presence of a dishwasher and the number of loads washed per week.

Table 19. Default Values for Calculating Dishwasher Water Usage

	Use_{day} (gallons/day)	# of $Loads_{week}$	Use_{load} (gallons/load)	Load Energy (kWh/load)
Simple inputs	3.4[a]	-	-	0.78[b]
Detailed inputs	6.3	4[a]	11[c]	0.78[b]

Notes:
[a] (Koomey et al. 1994) Table 4
[b] DOE 1990, page 3-8 Table 3.4
[c] (Lutz, et al. 1996) Table 4

3.3.6 Stove and Oven Energy Consumption

3.3.6.1 Stove Energy Consumption

In the Home Energy Saver, users are allowed to select between electric and gas stoves. Equation 21 describes the method used to calculate energy consumption by electric stoves. Equation 22 is used with gas stoves.

$$EC = power \times usage_{day} \times 365 \qquad \textbf{Equation 21}$$

where

EC = Annual energy consumption in kWh
power = energy consumption rate of stove (kWh/hour)
$usage_{day}$ = hours of use per day for all burners combined
365 = days per year

For electric ranges, the power consumed is assumed to be 1 kW for the purposes of this model (PG&E 1995).

$$EC = (burner\_rate \times usage_{day} \times 365) + pilotLight \qquad \textbf{Equation 22}$$

where

EC = Annual energy consumption in therms
burner_rate = energy consumed by stove (therms/hour)
$usage_{day}$ = hours of use per day for all burners combined
365 is days per year
pilotLight = energy consumed by the pilot light (therms/year)

For gas ranges, the rate of energy use is assumed to be 0.09 therms/hour and pilot light consumption is 17 therms/year (PG&E 1995). The default usage is 1 hour per day for both electric and gas ranges.

3.3.6.2 Oven Energy Consumption

In the Home Energy Saver, users are allowed to select either an electric and gas oven. Equation 23 describes the method used to calculate energy consumption by electric ovens. Equation 24 is used for gas ovens.

$$EC = power \times usage_{week} \times 52 \qquad \textbf{Equation 23}$$

where

EC = Annual energy consumption in kWh
power = energy consumed by oven (kWh/hour)
$usage_{week}$ = hours of use per week for the oven
52 = weeks per year

For electric ovens, the power consumed is assumed to be 2.3 kWh/hour [or 2.3 kW] for the purposes of this model (PG&E 1995). For gas ovens,

$$EC = (oven\_rate \times usage_{week} \times 52) + pilotLight \qquad \textbf{Equation 24}$$

where

EC = Annual energy consumption in therms
oven_rate = energy consumed by stove (therms/hour)
$usage_{week}$ = hours of use per week for all burners combined
52 is weeks per year
pilotLight = energy consumed by the pilot light (therms/year)

For gas ovens, the energy consumed is assumed to be 0.11 therms/hour and pilot light consumption is 17 therms/year (PG&E 1995). The default usage for all ovens is assumed to be 2 hours per week, regardless of oven fuel.

3.3.6.3 User Inputs to the Stove and Oven Model

Users are able to alter the inputs for stoves and ovens only in the detailed inputs model. Table 20 details the initial assumptions used for calculating stove and oven energy.

Table 20. User Inputs for Stoves and Ovens

Variable Name	Range of possible Values	Default Value	unit
Stoves			
StoveFuel	Electric Gas	Electric	
Usage	0 – 10 hours	1	Hours/day
Ovens			
OvenFuel	Electric Gas	Electric	
Usage	0 – 10 hours	2	Hours/week

3.4 Miscellaneous Equipment Energy Consumption

3.4.1 General Methodology

The model allows estimation of energy consumption for about seventy-five miscellaneous gas and electric appliances, with default values based on data compiled over the years by LBNL researchers. As with the other modules, default values can be over-ridden by the user to create a more accurate characterization of the type and use of miscellaneous equipment in the home.

The miscellaneous appliance category contains a varied assortment of small and/or unusual devices that could occur in a house, both electricity and gas. They are divided into several main categories; Entertainment, Home Office, Miscellaneous Kitchen Appliances, Hot Tubs and Spas, and Other Appliances. Energy for a particular piece of equipment is calculated according to the following equation and summed across all miscellaneous equipment to get total miscellaneous equipment energy consumption.

$$UEC = \left(\frac{ActivePower + StandbyPower}{1000}\right) \times NumberMachines \qquad \textbf{Equation 25}$$

where

UEC = annual energy consumed by the equipment (kWh)
ActivePower = ((P1 * P1Usage) + (P2 * P2Usage) +... + (Pn * PnUsage))
Pn = the energy consumed at various power levels (e.g. active use, on but idle etc.)
PnUsage = hours per year the equipment spends at this power rate.
StandbyPower = (8760 – Sum(all active Usages)) * StandbyRate
StandbyRate = energy consumed in standby mode
1000 converts WattHours to kWh.
NumberMachines = the quantity of this type of equipment in the house.

Typical energy consumption rates (both Active and Standby rates) for each piece of equipment as well as standard patterns of usage are documented in Table 21. We selected the default set of miscellaneous equipment types present in a house by examining the national saturation for each type. Those devices for which Sanchez (1998) estimated a national saturation greater than 80% were selected as part of the default set for all houses.

At the detailed inputs level, users can add and remove specific miscellaneous equipment types from the default set, and specify the usage for each item. Table 21 lists the equipment types present in the Home Energy Saver, showing the number of instances of this type of equipment included in the default set for all houses, the energy consumption for various modes of activity, both per unit time and annual totals, and the default usage assumption.

Table 21. Default Energy Consumption and Characteristics for Misc. Equipment

Appliance	Number Present in Default House	Estimated Wattage	Usage Increment	Usage Period	Season Increment (Months/ Year)	Active Usage (hours/ Year)	Active consumption	Standby Wattage	Standby Usage (hour/yr)	Standby consumption	Total kWh
Home Entertainment											
Boom Box	1	8	30	minutes / week		26	0	5.2	8734	45	46
Cable Boxes (standby losses)	1	140	90	minutes / day		548	77	11.6	8213	95	172
CD Player	1	7	30	minutes / week		26	0	3.7	8734	19	19
DVD Player	0	16	4	hours / week		208	3	5.5	8552	14	17
Receiver	1	28	2	hours / week		104	3	2.8	8656	24	27
satellite stations (standby losses)	0	25	2	hours / week		104	3	15	8656	130	132
Tape Player	1	8	2	hours / week		104	1	1.0	8656	9	9
Telephone Answering Machine	1	4.5	24	hours / day		8760	39	2.2	0	0	39
TV (CRT - Projection)	0	225	2	hours / day		730	164	6.4	8030	51	216
TV (CRT)	2	60	2	hours / day		730	44	6.4	8030	51	95
TV (DLP)	0	175	2	hours / day		730	128	6.4	8030	51	179
TV (LCD)	0	150	2	hours / day		730	110	6.4	8030	51	161
TV (Plasma)	0	300	2	hours / day		730	219	6.4	8030	51	270
VCRs	1	18	2	hours / week		104	2	5.3	8656	46	48
Video Games	1	20	1	hour / day		365	7	0	8395	0	7
Home Office											
Computer CPU	1	68	5	hours / day		1825	124	1.2	6935	8	132
home copiers	0	800	30	minutes / day		183	146	5.1	8578	44	190
Home facsimile machines (thermal)	0	175	4	minutes / day		24	4	30	8736	131	135
Home fax/Multi-function device (inkjet)	0	18	4	minutes / day		24	0	8	8736	70	70
Laptop Charger	0	0	0			0	0	4.5	8760	39	39
Monitor	1	84	5	hours / day		1825	153	2.0	6760	14	167
Printers (Inkjet)	1	13	1	hour / week		52	1	4.2	8708	37	37
Printers (Laser)	0	250	1	hour / week		52	13	4.2	8708	37	50
Router/DSL/Cable Modem	1	6	5	hours / day		1825	11	2	6935	14	25

Hot Tub, Pools and Pumps											
Pool Heater	0	275	6	hours / day	4	730	201	0	8030	0	201
Pool Pump	0	2250	6	hours / day	4	730	1643	0	8030	0	1643
Spa (24 hour elec)	0	0	0	hours / day		0	0	263	8760	2300	2300 kWh
Spa (24 hour gas)	0	0	0	hours / day		0	0	12	8760	105	105 therms
Spa (on-demand elec)	0	5500	4	hours / week		208	1144	0	0	0	1144 kWh
Spa (on-demand gas)	0	1.5	4	hours / week		208	0	0	0	0	312 therms
Sump/Sewage Pump	0	1/3 hp	25	hours / year		0	25	0	8760	0	9
Well Pump	0	0	0			0	0	0	8760	0	0
Misc. Kitchen											
Bottled Water Dispenser	0	0	0			0	0	34	8760	300	300
Broilers	0	1400	1	hour / week		52	73	0	8708	0	73
Coffee Maker: Drip (Brew)	1	1500	30	minutes / day		183	274	1	8578	9	282
Coffee Maker: Drip (Warm)	0	70	1	hour / day		365	26	0	8395	0	26
Coffee Maker: Percolater (Brew)	0	600	30	minutes / day		183	110	0	8578	0	110
Coffee Maker: Percolater (Warm)	0	80	1	hour / day		365	29	0	8395	0	29
Compactors	0	400	20	minutes / day		122	49	0	8638	0	49
Deep Fryer	0	1000	23	minutes / week		20	20	0	8740	0	20
Espresso Maker	0	360	1	hour / week		52	19	0	8708	0	19
Fry Pans	0	1000	14	hours / month		162	162	0	8598	0	162
Instant Hot Water	0	0	0			0	0	18	8760	160	160
Microwaves	1	1000	13	minutes / day		79	79	2.8	8681	24	103
Slow Cookers	0	200	13	hours / week		693	139	0	8067	0	139
Toaster	1	1100	6	minutes / day		37	40	0	8724	0	40
Toaster Oven -Toasting	0	460	4	minutes / day		25	12	0	8735	0	12
Toaster Oven - Oven	0	1500	23	minutes / day		140	210	0	8620	0	210
Other Miscellaneous											
Aquariums	0	63	24	hours / day		8760	548	0	0	0	548
Auto Engine Heaters	0	1500	1	hours / day	5	152	228	0	8608	0	228

Clock	2	0	0			0	0	1.0	8760	9	9
Dehumidifiers	0	46	24	hours / day		8760	400	0	0	0	400
Doorbell	1	0	0			0	0	5	8760	44	44
Electric Blankets	0	400	5	hours / day	2	304	122	0	8456	0	122
Electric Grills	0	1800	5	hours / week	5	108	195	0	8652	0	195
Electronic Air Cleaner/Filter	0	50	3	hours / day		1095	55	0	7665	0	55
Garage Door Openers	0	400	8	minutes / day		49	19	2.8	8711	24	44
Gas Grills	0	0.33	5	hours / week	5	108	36	0	8652	0	0
Gas Lighting	0	0.24	6	hours / week	3	78	19	0	8682	0	0
Hair Dryers	1	710	8	minutes / day		49	35	0	8711	0	35
Heat Tape	0	1000	1	hours / day	3	91	91	0	8669	0	91
Humidifier	0	11	24	hours / day		8760	100	0	0	0	100
Irons	0	1100	55	minutes / week		48	53	0	8712	0	53
Pipe and Gutter Heaters	0	500	2	hours / day	3	183	91	0	8578	0	91
Rechargable Handheld Vacuum (charging)	0	0	0			0	0	5	8760	44	44
Vacuum - Canister	0	818	1	hour / week		52	43	0	8708	0	43
Vacuum-Upright	1	297	1	hour / week		52	15	0	8708	0	15
Water Bed Heaters	0	0	0			0	0	102	8760	900	900

(blue)	Data from Sanchez et al, 1998
(green)	Data from Nordman et al. 2004.
(purple)	Data from Ross, et al. 2000.
(orange)	Average wattage determined by web search of typical units
(pink)	Average pump capacity (horsepower) taken from Granger Catalog search of sump pumps.
(cyan)	Data from CCAP spreadsheet (CCAP_040905)
(white)	Non colored values calculated from colorcoded source values

3.4.2 Well-pump energy calculation method

To calculate electrical energy for well pumps, we first calculate the energy needed to lift and pressurize the water for delivery to the home, then divide by the overall efficiency of the pump and motor system (Wateright 2003 and Greenberg 2005). The amount of energy required is a function of the amount of water consumed by the household. We estimate annual indoor water consumption using the following equation developed through a water end-use metering study (Mayer et al. 1999).

$$AIC = (37.2 \times occupants + 69.2) \times 365 \qquad \textbf{Equation 26}$$

where:

AIC	= Annual indoor water consumptions (gallons)
Occupants	= total number of household occupants
365	= converts daily to annual consumption

Outdoor water consumption is estimated using data from Mayer et al. (1999).[7] Because outdoor water use depends heavily on house-specific usage patterns (e.g., landscaping or swimming pools), we allow the user to select their outdoor water usage category, shown in Table 22.

Table 22. Outdoor Annual Water Consumption per Household

Outdoor water usage category[a]	Outdoor water consumption (thousand gallons per year)
Roughly 5 min/day	10[b]
Roughly 30 min/day	50[b]
Roughly 45 min/day	84.7[c]
Roughly 1.25 hours/day	150[d]
Roughly 2 hours/day	200[b]
Roughly 2.75 hours/day	300
Roughly 3.5 hours/day	400

Notes:
[a] Watering times assumes a typical garden house with 5 gal/min flow rate.
[b] These values are drawn from Mayer et al., table 5.14. All other values are extrapolations extending the range for use as a user input.
[c] This is the mean value of outdoor water use reported by Mayer et al. (146,100 gallons mean annual household consumption, with 58% of that amount allocated to outdoor uses).
[d] Default value.

$$WP = \frac{TDH \times GPM}{3960} \qquad \textbf{Equation 27}$$

where:

WP	= Annual average water power (hp)
TDH	= Total Dynamic Head (feet)
GPM	= Annual average flow rate of well (gallons per minute)

[7] The Mayer et al. study shows that indoor water use is relatively constant across the country, but outdoor water use can vary by a factor of 20 or more between regions of the country. A possible future improvement to our water use model would be to use the Mayer et al. study to estimate the relationship between climate and outdoor water use.

= Annual water consumption (gallons per year) ÷ 525,600 (min/year)
3960 = Unit conversion constant (feet•gallons/minute to horsepower)

To calculate total dynamic head (TDH), we use the following equation.

$$TDH = WellDepth + AdditionalHeight + pressurizationHead$$ **Equation 28**

where:

AdditionalHeight = Additional Height from well head to house

In practice, dynamic head would be a function of the depth to water and also include a term for friction losses in the piping. To simplify our calculations and make it easier for the user to describe their well system, we calculate dynamic head using the well depth (which will always be greater than the depth to water) and ignore piping friction losses, under the assumption that these two factors approximately cancel each other out. As a default, we assume that the average residential well in the U.S. is 150 feet deep. Because pressurization head (the pressure at which water is delivered to the piping in the house) is normally expressed using units of pressure (rather than feet of head), we convert from pressure to head using a ratio of 2.31 feet of head per psi. We assume 50 psi as a typical pressurization level for residential water systems supplied by wells. Pressurization head is only included if the user indicates that the water pressure in their house is provided by a water pump (versus gravity flow from storage).

$$EP = WP \times 0.746 \times \frac{1}{\eta_s}$$ **Equation 29**

where:

EP = Electrical power (kW)
WP = Water power (hp)
η_s = Overall efficiency of pump and motor system (decimal value, 0 to 1)

The efficiency of pump and motor systems can vary widely depending on the type of pump and motor, well configuration, and maintenance practices. Representative values for efficiency are not published, but it has been suggested that overall efficiencies between 0.15 and 0.60 are typical. For modeling in HES, we assume a combined efficiency of 0.40 for residential well pump/motor systems. For modeling best available pump/motor systems, we assume a combined efficiency of 0.60.

Finally, we calculate annual energy consumption for well pumping using the following equation:

$$PumpingEnergy = EP \times 8760$$ **Equation 30**

where:

8760 = hours per year

3.5 Lighting Energy Consumption

Accurately estimating the energy consumption of lighting requires detailed information about the technical specification of the fixture and the typical usage pattern for that fixture. Since not all consumers are willing or able to provide that level of detail, the Home Energy Saver offers a means to arrive at lighting consumption with minimal user input as well as a more complete calculation model. Lighting fixtures are grouped according to the room in which they are located. Equation 31 calculates the lighting energy consumption for all fixtures in a room. Lighting consumption at the household level is simply the sum of energy consumed by all rooms.

$$EC = \sum_{i=1}^{n} FE_i$$ **Equation 31**

where

EC = Annual lighting energy consumption by room (kWh/year)
FE = Fixture energy (kWh/year)
n = number of fixtures in room

The fixture energy represents the energy consumption of both the lamp and ballast components of a light fixture. A fixture consists of all the lamps controlled on a single circuit. Fixture energy is calculated using Equation 32.

$$FE = \left(\frac{P_{lamp} + P_{ballast}}{1000} \right) * usage * 365$$ **Equation 31**

where

P_{lamp} = combined power for all lamps in fixture (Watts)
$P_{ballast}$ = total ballast power for fluorescent fixtures (Watts)
usage = fixture usage (hours/day)
365 is days per year

Note that ballast energy is only applicable for fluorescent tube fixtures. Any ballast energy for compact fluorescent fixtures and halogen fixtures is included in the total lamp wattage for the fixture, entered by the user. Ballast fixture power is given by

$$P_{ballast} = 130 * \left(\frac{NL}{2} \right)$$ **Equation 32**

where

130 = Ballast power (Watts)
NL = number of lamps in fixture
[Note (NL/2) is rounded to next-higher integer value]

3.5.1 User Inputs to the Lighting Model

At the simple inputs level of modeling, users are asked to specify the number of fixtures per room. The model then estimates the energy consumption per room, using default values based on the appropriate room (Table 22), derived from a Tacoma Public Utilities Study (Jennings et al. 1997; Tribwell and Lerman 1996). Where these default data are used, all fixtures in the room are considered to be identical. Alternatively, at the detailed inputs level of modeling, users are able to enter lamp type, number of lamps/fixture, total fixture wattage and usage individually for every fixture.

Table 23. Default Lighting Fixture Parameters

Room	Lamp Type	# of Lamps / Fixture	Ave. Lamp Power (W)	Ave. Fixture Power (W)	Usage (hr/day)	Annual UEC by Room (kWh)
Kitchen	Incandescent	2	59	95	3	218
Dining Room	Incandescent	3	62	165	2	136
Living Room	Incandescent	1	98	124	2	109
Family Room	Incandescent	1	73	106	2	77
Master Bedroom	Incandescent	1	68	93	1	81
Bedroom	Incandescent	1	68	94	1	73
Closet	Incandescent	1	60	66	1	0
Bath	Incandescent	2	70	138	2	192
Hall	Incandescent	1	65	78	2	98
Utility	Incandescent	1	62	84	2	0
Garage	Incandescent	1	75	103	2	71
Outdoor	Incandescent	1	84	110	3	231
Other	Incandescent	1	72	103	1	0

Notes:
1) Number of lamps derived from average Lamp and Fixture power.
2) Available lamp types are Incandescent, Halogen Torchiere, Compact Fluorescent and Fluorescent tubes
3) Allowable usage is from 0 to 24 hours/day

4. Default Energy Consumption and House Configuration

4.1 Average Energy Bills for Existing Houses

In order to provide users an initial estimate of energy savings potential in their house, we estimated average energy bills by climate region from the sample of single-family housing units (including manufactured homes) in the 1993 and 2001 RECS microdata (US DOE 1995a, US DOE 2004). Users see this information immediately following entry of the zip code.

Energy bills by end-use are based on the end-use consumption estimates reported in the RECS microdata. For each housing unit in the RECS sample, EIA reports the Census Division in which that housing unit is located, as well as summary climate data (HDD and CDD) from the geographically closest weather station.

In order to provide finer geographic disaggregation of the RECS data, we assign each of the RECS housing units to one of 19 climate regions in the U.S. These climate regions were originally developed by LBNL in a project for the Gas Research Institute (Ritschard et al. 1992) and extended by Huang (Huang et al. 1999) and Apte (Apte 2004). The 19 climate zones are described in Table 24. Using these climate-region assignments, within each climate region we select those single-family housing units that have the most common heating and cooling characteristics (heating fuel, water heating fuel, and presence of central air conditioner) for that region.

The energy consumption for space heating, space cooling and water heating was determined from this subset of housing units. Energy consumption for appliances was derived from the full set of single-family housing units for each climate zone. The 2001 Residential Energy Consumption Survey has not included data on lighting consumption since 1993, so the lighting energy consumptions was taken from the 1993 RECS microdata (US DOE 1995a). The final consumption values are shown in Appendix B, Default Energy Consumption

Table 24. Climate Zone Assignment

Division	Heating/Cooling Days	Climate Zone
New England	any	1
Mid-Atlantic	any	2
East No. Central	any	3
	(No zone four)	
West No. Central	HDD65 > 7000	5
West No. Central	HDD65 < 7000	6
So. Atlantic	HDD65 >= 4000	7
So. Atlantic	HDD65 < 4000 and CDD65 < 3000	8
So. Atlantic	HDD65 < 4000 and CDD65 > 3000	9
East So. Central	HDD65 >= 4000	10
East So. Central	HDD65 < 4000	11
West So. Central	HDD65 >= 2000	12
West So. Central	HDD65 < 2000	13
Mountain	HDD65 >= 7000	14
Mountain	5000 < HDD65 < 7000	15
Mountain	HDD65 < 5000 and CDD65 < 2000	16
Mountain	HDD65 < 5000 and CDD65 > 2000	17
Pacific	HDD65 > 4000	18
Pacific	2000 < HDD65 < 4000	19
Pacific	HDD65 < 2000	20

The climate zone assignment is determined by the Census division and heating and cooling degree days (see Table 24) which are directly taken from the RECS micodata set. We determine the most common characteristics through the default house analysis described in section 3.1.2. These characteristics, and the number of RECS records meeting those criteria, are shown in Table 25. We select only the houses that had the most common characteristics because we want their average energy use to correspond to the default house characteristics for that region (to provide internal consistency within the HES model).

The default energy consumption values from the RECS survey and the calculated energy consumption values returned from the DOE 2.1E building simulation model are converted from Mbtu to utility units (kWh, therm, etc.) for presentation to the user, using the following equations.

Electricity:

$$Energy_{kWh} = Energy_{Mbtu} * \ 1{,}000{,}000 / 3412 \qquad \textbf{Equation 33}$$

Natural Gas:

$$Energy_{therm} = Energy_{Mbtu} * \ 10 \qquad \textbf{Equation 34}$$

Fuel Oil (gallon of fuel oil):

$$Energy_{gallon} = Energy_{Mbtu} * \ 1{,}000{,}000 / 138{,}690 \qquad \textbf{Equation 35}$$

Liquid Propane Gas (gallon):

$$Energy_{gallon} = Energy_{Mbtu} * \ 1{,}000{,}000 / 85{,}786 \qquad \textbf{Equation 36}$$

Table 25. Typical Heating and Cooling Characteristics for Each Climate Zone

Climate Zone	Heating Fuel	Water Heating Fuel	Central Cooling?	Number of Housing Units
1	Fuel Oil	Fuel Oil	No	3656165
2	Natural Gas	Natural Gas	Yes	9005530
3	Natural Gas	Natural Gas	Yes	13267528
5	Natural Gas	Natural Gas	Yes	1975960
6	Natural Gas	Natural Gas	Yes	4258550
7	Natural Gas	Natural Gas	Yes	3693237
8	Electricity	Electricity	Yes	9473774
9	Electricity	Electricity	Yes	3151667
10	Electricity	Electricity	Yes	1080956
11	Natural Gas	Natural Gas	Yes	4855664
12	Natural Gas	Natural Gas	Yes	5026693
13	Natural Gas	Natural Gas	Yes	4584481
14	Natural Gas	Natural Gas	No	1011371
15	Natural Gas	Natural Gas	No	2244047
16	Natural Gas	Natural Gas	No	434697
17	Natural Gas	Natural Gas	No	1700087
18	Natural Gas	Natural Gas	No	3267745
19	Natural Gas	Natural Gas	No	2998674
20	Natural Gas	Natural Gas	No	4809105

4.2 Bill Savings in Typical Houses due to Energy Efficiency Upgrades

In order to provide users an idea of how much they could potentially save on their energy bills, we have estimated technical savings potentials for typical houses in U.S. regions. These estimates of savings potential are applied to the average existing energy bills by climate region, as described in the previous section. Users see this information immediately following entry of their zip code.

To estimate the potential savings, we select a single house from the 1990 RECS sample to represent each census division. These houses are selected such that their utility bills are within 10% of the median value in each census division, and they have the heating and cooling equipment most common in that census division. These selected houses are single-family detached, with floor area ranging from 1100 to 2900 square feet. 1990 RECS utility bill data are inflated to 1995 dollars using the Consumer Price Indices for electricity, piped gas, and fuel oil. The characteristics of the selected houses are shown in Table 26.

We then estimate the utility bills for these houses, assuming that "best available" technology were applied to the building shell and the equipment contained in that house (according to the RECS survey). Best available technology is generally defined as the most efficient products on the market. The savings estimates are based on several sources, including an LBL supply curves analysis (Koomey et al. 1991) and unpublished updates to that analysis; the U.S. DOE Water Heater standards analysis (U.S. DOE 2000c); a U.S. EPA analysis of space conditioning efficiency improvements (L'Ecuyer et al. 1993); the Honeywell Thermostat Energy Savings Estimator program (Honeywell 1994); Mark Modera (1998); and model directories from the Air conditioning and Refrigeration Institute (ARI 1995), Gas Appliance Manufacturers Association (GAMA 1996), and the California Energy Commission (CEC 1998). The resulting savings factors are shown in Table 27. For lighting, we assume 50% savings are achievable with a combination of compact fluorescent lamps and outdoor lighting controls.

4.3 Carbon Emissions in Typical Houses

To estimate carbon emissions (as CO_2) for the default house consumption (Typical House), we use regional emission factors for electricity, and national emission factors for fuel-fired appliances and equipment. For electricity, we developed regional emissions factors using total emissions for fossil steam generation units (US DOE 1996), divided by net generation in each census division.[8] We then added 8% transmission and distribution losses. Finally, we scaled up to account for the additional generation (roughly 2% nationally, but different regionally) that is associated with combustion turbines and internal combustion engines. This approach assumes that the combustion turbines and IC engines have, on average, the same emissions per kWh as the other fossil-steam plants. The resulting values are annual averages for all electricity generated within that region. The resulting emission factors are shown in Table 28.

[8] This methodology accounts for zero-emission generation from hydro, nuclear, and renewables.

Table 26. Estimated Utility Bills After Switching to ENERGY STAR or Best Available Technology

Census Division	City	Heat Fuel	CAC	# RAC	1995 $ Water Heat Fuel	Baseline Bill ($1995/year) Total Utility Bill	Space Heat	Space Cool	Water Heat	Appl-iances	Total Bill
New England	Worcester, MA	fuel oil	no	1	fuel oil	$1,621	$728	$24	$162	$707	$1,621
Mid Atlantic	Philadelphia, PA	natural gas	no	2	natural gas	$1,891	$695	$201	$212	$784	$1,891
East North Central	Springfield, IL	natural gas	no	0	natural gas	$1,783	$686	$0	$302	$794	$1,783
West North Central	Minneapolis, MN	natural gas	yes	0	natural gas	$1,023	$463	$73	$127	$360	$1,023
South Atlantic	Charleston, SC	electricity	yes	0	electricity	$1,073	$134	$391	$121	$427	$1,073
East South Central	Nashville, TN	electricity	yes	0	electricity	$1,266	$316	$234	$238	$478	$1,266
West South Central	Dallas, TX	natural gas	yes	0	natural gas	$1,312	$297	$454	$113	$448	$1,312
Mountain North	Denver, CO	natural gas	no	0	natural gas	$1,301	$459	$0	$142	$700	$1,301
Mountain South	Phoenix, AZ	electricity	yes	1	electricity	$1,054	$109	$334	$152	$458	$1,054
Pacific North	Seattle, WA	electricity	no	0	electricity	$998	$577	$0	$97	$323	$998
Pacific South	Los Angeles, CA	natural gas	yes	0	natural gas	$1,058	$130	$305	$59	$564	$1,058

Table 27. Estimated Utility Bill Savings After Switching to ENERGY STAR or Best Available Technology

Census Division	% Bill Savings for Energy-Efficient House Space Heat	Space Cool	Water Heat	Appl-iances	Total Bill
New England	63%	33%	50%	35%	49%
Mid Atlantic	66%	33%	50%	33%	47%
East North Central	66%	62%	50%	33%	49%
West North Central	66%	59%	50%	34%	52%
South Atlantic	65%	62%	43%	35%	50%
East South Central	65%	62%	43%	35%	49%
West South Central	67%	62%	50%	35%	53%
Mountain North	66%	62%	50%	35%	48%
Mountain South	65%	62%	43%	35%	48%
Pacific North	65%	62%	43%	35%	63%
Pacific South	67%	62%	50%	34%	47%

Table 28. Electricity Carbon Emission Factors (as CO_2) for Typical Houses

Census Division	Emissions (lb. CO2/kWh.e)
New England	0.91
Middle Atlantic	1.13
East North Central	1.71
West North Central	1.90
South Atlantic	1.39
East South Central	1.69
West South Central	1.63
Mountain North	1.98
Mountain South	1.46
Pacific North	0.23
Pacific South	0.48
Total US	1.45

Notes:
1. Mountain South region includes Arizona and New Mexico. Mountain North region includes all other states in the Mountain census division.
2. Pacific South region includes California and Hawaii. Pacific North region includes all other states in the Pacific census division.

5 Bill calculation

There are two primary methods used to calculated the electric bills in the Home Energy Saver. The default method utilizes state level energy prices and the tariff method, where users can select an electricity tariff. For non-electric fuels, state level prices are used to calculate the annual bill for that fuel.

5.1 Default Energy Prices

When users first enter the Home Energy Saver site, they are assigned default energy prices based on the state in which their ZIP code is located. These default energy prices are the most recent available state averages from either 2004 (for electricity and natural gas) or 2000 (for LPG and fuel oil), summarized in Table 29. All energy price data are from the U.S. DOE's Energy Information Administration (US DOE 2000b, 2004a, 2004b). For many locations, users also have the option of selecting actual utility tariffs (see Section 5.2).

Table 29. Default Energy Prices

State	**Electricity** (2004$/kWh)	**Natural Gas** (2004$/therm)	**LPG** (2000$/gallon)	**Fuel Oil** (2000$/gallon)
Alabama	0.07550332	0.919	1.406533347	1.158065481
Alaska	0.123869546	0.358	1.68875335	1.336976196
Arizona	0.084730303	0.943	1.454940015	0.998571433
Arkansas	0.074419614	0.743	1.342600013	1.165000005
California	0.117833685	0.821	1.486906682	1.493696435
Colorado	0.083196086	0.614	1.149886678	1.285660719
Connecticut	0.116426135	1.143	1.707020017	1.368875006
Delaware	0.087991669	0.833	1.506086682	1.270404767
Florida	0.089458279	1.293	1.759993351	1.374422625

Georgia	0.079369654	0.838	1.473206681	1.349458339
Guam	0.123	1.649	1.545	1.007
Hawaii	0.18062334	2.187	2.70529336	1.449315482
Idaho	0.060768554	0.628	1.203773345	1.228797624
Illinois	0.085149595	0.733	1.091433344	1.1636131
Indiana	0.073215318	0.642	1.234826679	1.267630958
Iowa	0.090570708	0.781	0.882280009	1.395226196
Kansas	0.078174262	0.764	0.979093343	1.495083339
Kentucky	0.060845897	0.741	1.34442668	1.263470243
Louisiana	0.080924757	0.834	1.467726681	1.158065481
Maine	0.126276068	0.971	1.549013349	1.364714291
Maryland	0.080024497	0.978	1.665920017	1.418803577
Massachusetts	0.118464588	0.991	1.674140017	1.336976196
Michigan	0.0854987	0.511	1.173633345	1.334202386
Minnesota	0.080574072	0.713	1.072253344	1.231571434
Mississippi	0.081715096	0.749	1.449460014	1.191351195
Missouri	0.070626678	0.785	1.044853344	1.295369053
Montana	0.078361902	0.603	1.065860011	1.1636131
Nebraska	0.069128322	0.643	0.916986676	1.103976195
Nevada	0.097001553	0.663	1.420233348	1.483988101
New Hampshire	0.125118314	1.007	1.386440014	1.281500005
New Jersey	0.112396716	0.728	1.767300018	1.488148816
New Mexico	0.087845155	0.61	1.227520012	1.169160719
New York	0.145845539	0.986	1.62025335	1.499244054
North Carolina	0.084427936	0.953	1.443066681	1.416029768
North Dakota	0.067689121	0.637	0.990053343	1.2509881
Ohio	0.084651967	0.77	1.285973346	1.281500005
Oklahoma	0.076739676	0.737	1.086866678	1.245440481
Oregon	0.071241995	0.812	1.345340013	1.367488101
Pennsylvania	0.09655694	0.849	1.591026683	1.296755958
Puerto Rico	0.123	1.649	1.545	1.007
Rhode Island	0.121931963	0.983	1.886946686	1.346684529
South Carolina	0.080530254	0.915	1.497866682	1.478440482
South Dakota	0.076387157	0.734	0.947126676	1.239892862
Tennessee	0.068791531	0.749	1.391920014	1.511726197
Texas	0.095951006	0.741	1.411100014	1.183029767
Utah	0.072422694	0.62	1.278666679	1.219089291
Vermont	0.130738145	0.813	1.457680015	1.317559529
Virginia	0.079935881	0.998	1.583720016	1.313398815
Virgin Islands	0.123	1.649	1.545	1.007
Washington	0.063567812	0.716	1.388266681	1.539464292
Washington DC	0.081417484	1.081	1.648566683	1.068074774
West Virginia	0.062263766	0.746	1.224449373	1.224449373
Wisconsin	0.091048799	0.755	1.058553344	1.230184529
Wyoming	0.070957775	0.611	1.064946677	1.210767862
Source:	(USDOE 2004a)	(USDOE 2004b)	(USDOE 2000b)	

5.2. Bill Calculations with Utility Block-Rate and Time-of-Use Tariffs

Consumer-oriented home energy calculators are only effective if they combine careful energy analysis with energy cost information in a fashion that yields meaningful energy *bills*. Energy tariffs (particularly those for electricity) are becoming increasingly complex, as they are redesigned to encourage efficient use of energy at the margin and management of peak demand. For example, the so-called "inverted block tariffs" present the user with increasingly high per-unit electricity prices as consumption rises. "Time-of-Use" tariffs present the user with high electricity prices at times when the utility system is likely to be facing peak demands (e.g. weekday afternoons), and correspondingly low prices at off-peak times.

Most energy calculators utilize highly stylized prices (e.g. a flat cents-per-kilowatt-hour value), which fail to capture the real-world conditions facing consumers. To address this void, the Home Energy Saver site includes actual electricity tariffs, which may be selected by the user instead of default electricity prices (described in Section 5.1 Default Energy Prices of this report).

An analysis of a home on Sacramento provides an illustration of the value of more realistic electricity price assumptions. Using an actual standard residential tariff from the local utility (SMUD) results in an annual cooling electricity bill that is 22% lower than that predicted using the statewide "default" average electricity price results. Conversely, using one of SMUD's TOU tariffs results in a bill that is 32% higher than the basic SMUD residential tariff. A subsequent thermostat setback reduces the TOU bill by 18%. The results would be even more dramatic for more extreme cooling climates.

Table 30. Comparison of Energy Bills with Using Utility Tariffs

Energy price	Annual bill ($/year)	% change from previous	Cooling bill ($/year)	% change from previous	July monthly bill ($)	tariff details
state average	$1,721		$189		n/a	12.2 ¢/kWh
SMUD res. tariff	$1,462	-15%	$148	-22%	$101	summer = 8 ¢/kWh up to 700 kWh, then 14 ¢/kWh, then 15.7 ¢/kWh
SMUD RTG	$1,687	15%	$196	32%	$143	summer on-peak = 19.8 ¢/kWh, off-peak = 8.5 ¢/kWh (summer peak = 2-8 pm)
SMUD RTG w/ t-stat setback	$1,550	-8%	$160	-18%	$131	t-stat setback from 9 am to 7 pm (78 to 81 degF)
SMUD RTG w/ t-stat setback	$1,525	-2%	$154	-4%	$123	t-stat setback from 2 pm to 9 pm (78 to 81 degF)

The purpose of this module is to allow users to compare their utility bills under alternative tariff scenarios, and to assess the potential bill savings from upgrades to the house or changes in behavior.

For TOU tariffs in particular there are a special set of consumer behaviors that can currently be modeled in HES to attain energy bill savings. Examples include:

- Use of the programmable thermostat module to represent setbacks/setups, etc.
- Technical measures to reduce air-conditioning demand (efficient equipment, roof color

change, etc)
- Energy-efficiency measures in general (savings apportioned to end-use load shape)
- Shifting to a different tariff
- Shifting to a non-electric fuel

Underlying our method, utility tariff data are stored in the Tariff Analysis Project (TAP) database (http://tariffs.lbl.gov/), and TAP is utilized to provide a web service for retrieving tariff data and calculating utility bills. Currently, 177 residential and agricultural tariffs from 87 utilities in 42 states are available in the TAP database. As new tariffs are entered into the database, they are automatically made accessible to HES users. We allow users to choose among residential as well as agricultural tariffs (as some homes located on farms will utilize an agricultural tariff).

With the exception of heating and cooling (which are currently modeled on an hourly basis), the end-use load shapes are static. Thus, users cannot currently define an alternate load shape and compute savings (e.g. to represent line-drying of clothes in summer), although this capability may be added in the future.

5.2.1 Tariff Analysis Project Database

TAP was originally developed to facilitate the analysis of electricity prices for the US Department of Energy's Appliance Efficiency Standards program. The tariff database and bill calculation applications have been used in particular for the Distribution Transformers and Commercial Unitary Air Conditioning Equipment rules.

The tariff analysis infrastructure consists of two primary components: a database containing the rate structure information and related data fields, and a web interface allowing users to enter, edit and view tariffs (http://tariffs.lbl.gov/). Starting from these components, a variety of applications can be built, including bill calculator programs, batch data-processing scripts, and methods that allow TAP to interface directly with other software.

One of the key innovations in the development of TAP is the design of a data-table format that is flexible enough to accommodate the wide range of tariff structures encountered in practice. This general data-table can be thought of as a "universal tariff template". TAP currently accommodates the following rate design features for electricity tariffs:

- Fixed, energy and demand charges
- Block rates with constant or variable block sizes
- Hours charges, seasonal rates, time-of use rates

In addition to the actual rates, understanding electricity pricing requires access to information about the variety of tariffs offered by a utility, including service types, customer classes, geographic constraints etc. This additional information is built into TAP, and allows the user of the database to sample the set of tariffs according to a wide variety of criteria.

Figure 10. Tariff Detail for Standard vs. TOU tariffs (from TAP).

Standard Block Tariff

Pacific Gas & Electric Co

http://www.pge.com/

H.Q. State: California

E.I.A. Code: 14328

SCHEDULE: E-1 E-1 RESIDENTIAL SERVICE TERRITORY P

Effective: 2004-06-17

Markets Served: Residential

Service Type: Residential

Energy Range: 0 and above kWh

Demand Range: 0 and above kW

This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E; to single-phase and polyphase service in common areas in a multifamily complex (see Special Condition 8); and to all single-phase and polyphase farm service on the premises operated by the person whose residence is supplied through the same meter.

Fixed Charges, ($ per month)

Annual Charges

Total Minimum Charge Rate		
Monthly Charge	$	5.00

Energy Charges, ($ per KWH)

Summer Charges

All day		
0 to 40.0 Kwh	$	0.0000
From previous value to 481.9 Kwh	$	0.1259
From previous value to 626.5 Kwh	$	0.1432
From previous value to 963.8 Kwh	$	0.1790
From previous value to 1445.7 Kwh	$	0.2097
All remaining kwh	$	0.2097

Winter Charges

All day		
0 to 40.0 Kwh	$	0.0000
From previous value to 393.4 Kwh	$	0.1259
From previous value to 511.5 Kwh	$	0.1432
From previous value to 786.9 Kwh	$	0.1790
From previous value to 1180.3 Kwh	$	0.2097
All remaining kwh	$	0.2097

TOU Tariff

Pacific Gas & Electric Co

http://www.pge.com/

H.Q. State: California

E.I.A. Code: 14328

SCHEDULE: E-7 RESIDENTIAL TOU SERVICE TERRITORY P

Effective: 2004-03-01

Markets Served: Residential

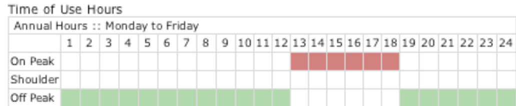
Service Type: Residential

Energy Range: 0 and above kWh

Demand Range: 0 and above kW

This voluntary schedule is available to customers for whom Schedule E-1 applies. The provisions of Schedule S—Standby Service Special Conditions 1 through 6 shall also apply to customers whose premises are regularly supplied in part (but not in whole) by electric energy from a nonutility source of supply. These customers will pay monthly reservation charges as specified under Section 1 of Schedule S, in addition to all applicable Schedule E-7 charges. See Special Conditions 10 and 11 of this rate schedule for exemptions to standby charges.

Time of Use Hours



Energy Charges, ($ per KWH)

Summer Charges

On-Peak		
0 to 481.9 Kwh	$	0.3252
From previous value to 626.5 Kwh	$	0.3252
From previous value to 963.8 Kwh	$	0.3635
From previous value to 1445.7 Kwh	$	0.3963
All remaining kwh	$	0.3963
Off-Peak		
0 to 481.9 Kwh	$	0.0952
From previous value to 626.5 Kwh	$	0.0952
From previous value to 963.8 Kwh	$	0.1334
From previous value to 1445.7 Kwh	$	0.1662
All remaining kwh	$	0.1662

Winter Charges

On-Peak		
0 to 393.4 Kwh	$	0.1264
From previous value to 511.5 Kwh	$	0.1264
From previous value to 786.9 Kwh	$	0.1646
From previous value to 1180.3 Kwh	$	0.1974
All remaining kwh	$	0.1974
Off-Peak		
0 to 393.4 Kwh	$	0.0985
From previous value to 511.5 Kwh	$	0.0985
From previous value to 786.9 Kwh	$	0.1368
From previous value to 1180.3 Kwh	$	0.1696
All remaining kwh	$	0.1696

*All prices are in US Dollars

5.2.2 User Interface for Tariff Module

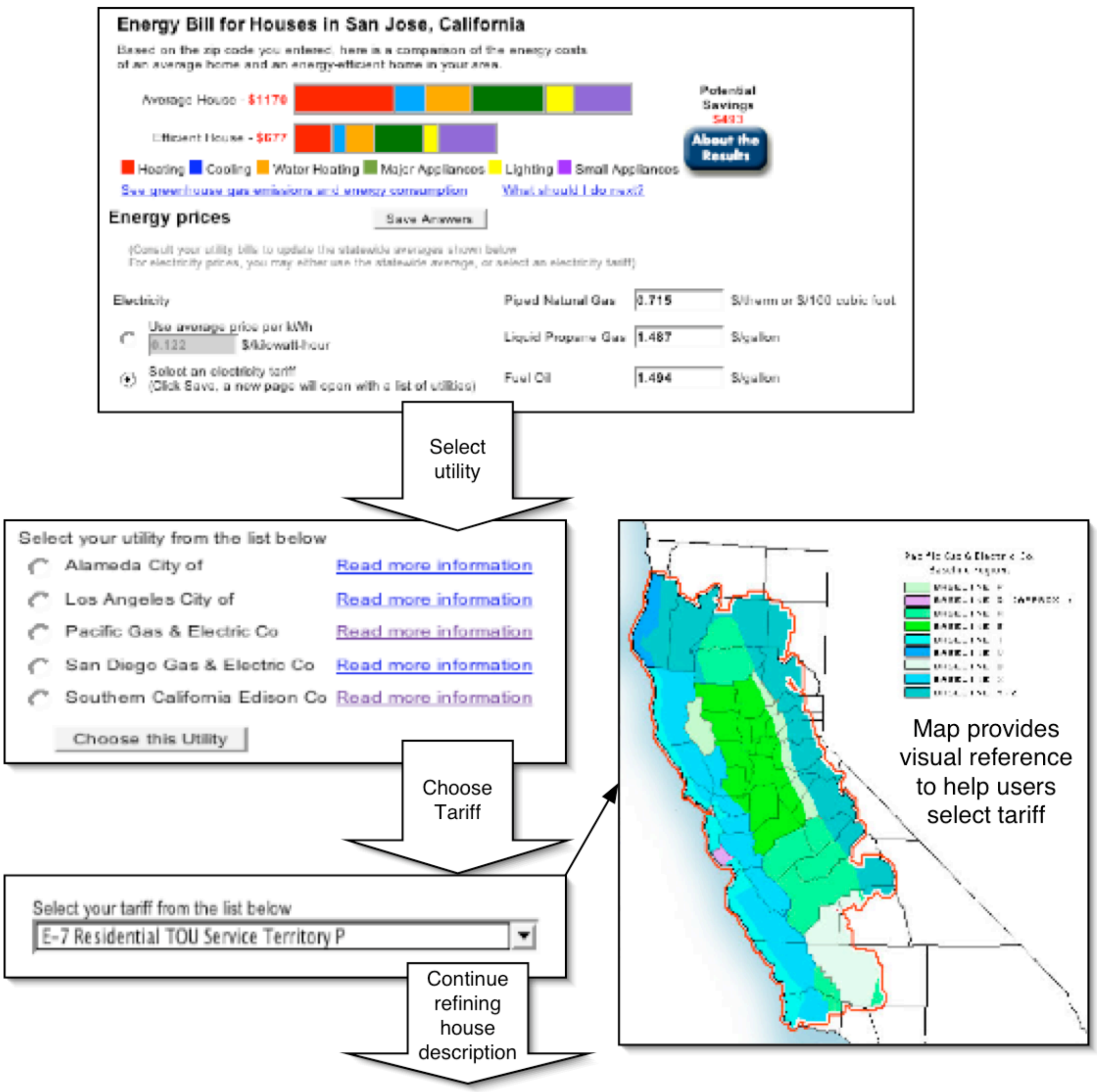
The HES user interface allows users to select a utility tariff, and to view the results of time-differentiated electricity bill calculations.

5.2.2.1 Tariff Selection

To select an electric utility tariff, users must specify their electric distribution utility, and the specific tariff they wish to analyze. The relationship between the input pages is shown in Figure 11. When editing their utility rates (on the existing HES energy prices input page), users can choose an option that starts the process of selecting a utility. Users may also make this choice to use a utility tariff rather than the state average prices from the Key inputs page. After selecting a ZIP code, users are asked to select their utility from a list of available utilities. The next page presents a list of available tariffs, based on their choice of utility[9]. After selecting a tariff, users return to continue refining their house description, or to initiate the calculation process.

Throughout this process, users retain the option to end the tariff selection and return to the default, annual-average rates, for cases where their utility is not available in the TAP database or they simply change their mind (by returning to the energy price page and selecting the radio button corresponding to the average electricity price).

Figure 11. Relevant HES Input Pages.



[9] Since large utilities in California typically have multiple climate zones, a link to a map showing the climate zones specific to the utility is given when available. The user can use this as a visual aid to refine their choice among the tariffs available for their utility

5.2.2.2 Presentation of Results

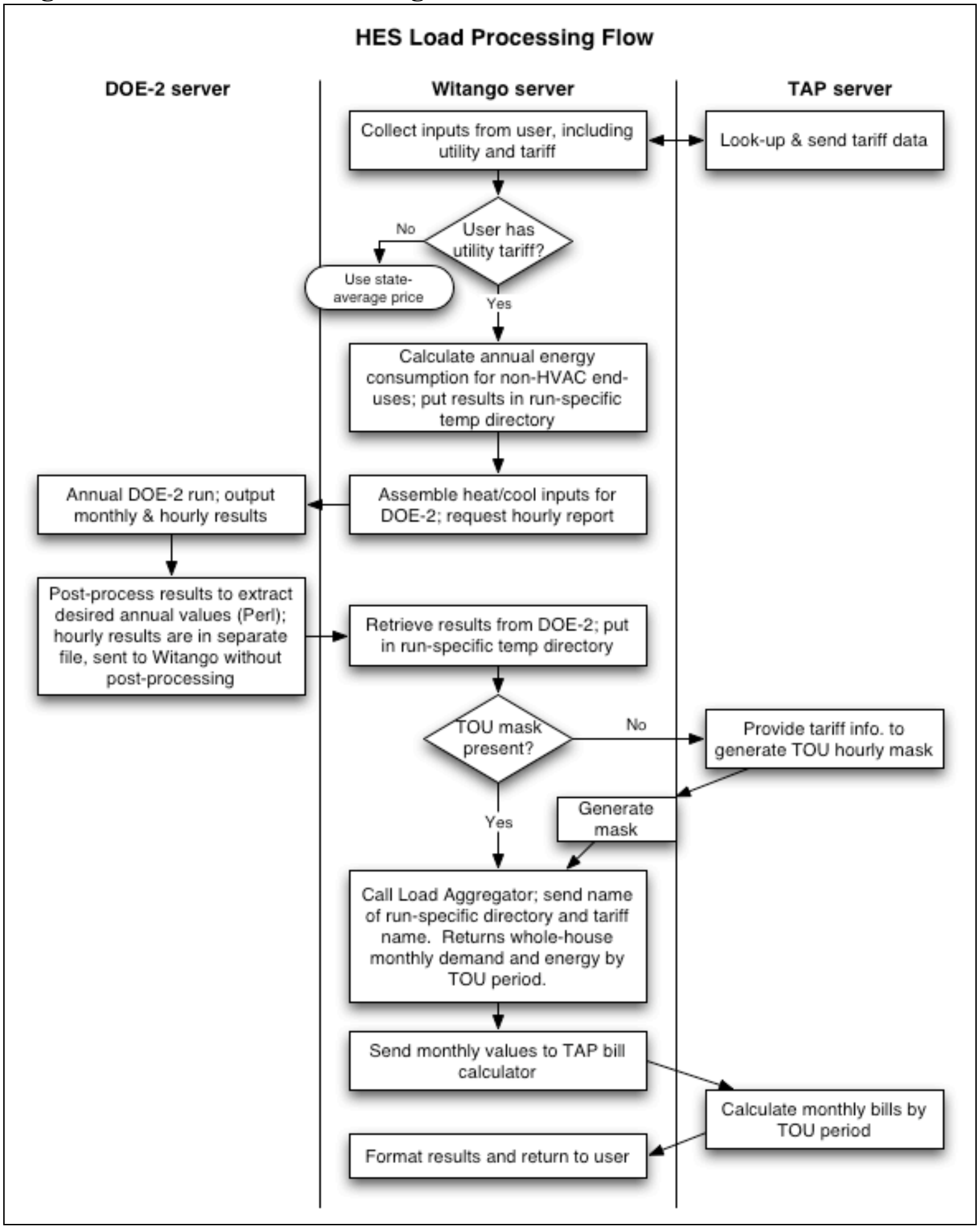
For users who choose not to use the utility tariff option, the HES result pages presents estimates of the house's annual energy consumption by end-use. Those users who select a utility tariff are provided with one or two additional results pages. Tariff analysis has added the capability to calculate energy use and peak demand by end-use within each month, and by Time-of-Use (TOU) period (for tariffs with TOU periods). As shown in Figure 6, when the user views the main results page (showing annual energy use by end-use), they are offered up to two additional choices from the blue buttons on the right side of the page. One button opens a page displaying their estimated monthly bills by end-use; the second links to a display of monthly bills by TOU period. The button linking to the monthly bills by TOU period is only present for those tariffs that contain TOU periods. These pages are small pop-up windows that display in front of the main results window. The user can close the pop-up window to return to the main results page.

5.2.3 Load Processing Algorithms

The core of the new HES functionality is a load processing "module" that translates annual electricity consumptions for several end-uses, along with hourly outputs from the DOE-2 model, into monthly utility bills.

Load processing follows the general flow shown in Figure 12. Three types of servers (DOE-2, Witango, and TAP) perform different parts of the load processing. To ensure consistency, all load calculations are based on the year 2005 calendar. There are several distinct steps necessary to transform annual electricity into monthly electricity bills. First, the non-HVAC end-uses (appliances, lighting, etc.) with similar load shapes need to be combined then allocated to an 8760-hour profile according to the appropriate load shape curve. Second, all the 8760 hourly profiles for the house (including the hourly output from the DOE-2 heating and cooling simulation engine) need to be aggregated to form the hourly profile for the house. This profile is used to identify the monthly peak demand in each TOU bin as well as the total monthly electricity consumption for each bin. These numbers are sent to TAP, which returns the monthly electricity bills. Finally these bills need to be allocated back to the individual appliances.

Figure 12. HES Load Processing Flow.



5.2.3.1 Annual Energy Consumption by End-Use

HES currently calculates annual energy consumption by end-use. In some cases, consumption for multiple end-uses is aggregated to correspond to the end-uses available in the load shape files provided by the California Energy Commission (CEC). This correspondence is shown in Table 31.

Table 31. Correspondence between HES and CEC End-uses

CEC		HES	
Full name	*Abbreviation*	*Appliance*	*Category*
Water heater	sfamd	Water heater (taps and faucets)	Water Heater (other water); Major Apps (dw and cw)
Refrigerator	refri	Refrigerator	Major Appliances
Freezer	freez	Freezer	Major Appliances
Cooking appliances	cooki	Stove + oven + misc. cooking[1]	Major Apps (stove, oven); Misc (misc. cooking)
Dishwasher	dishw	Dishwasher motor + water	Major Appliances
Clothes washer	washe	Clothes washer motor +water	Major Appliances
Clothes dryer	dryer	Clothes dryer	Major Appliances
Home entertainment appliances	telev	TV + VCR + audio + other home electronics	Miscellaneous appliances
Waterbed heater	water	Waterbed	Miscellaneous appliances
Spa heater	spahe	Empty at present	Miscellaneous appliances
Spa pump	spapu	ElecSpaEnergy	Miscellaneous appliances
Pool heater	plhea	Pool heater	Miscellaneous appliances
Pool pump	poolp	Pool pump	Miscellaneous appliances
Miscellaneous appliances	misc	Remaining misc. + lighting	Miscellaneous appliances and Lighting

Notes:
1. Misc cooking includes Broiler, Drip Coffee, Percolator Coffee, Deep Fryer, Electric Fry Pan, Espresso Machine, Microwave Oven, Slow Cooker, Toaster, Toaster Oven and Electric Grill.

5.2.3.2 Utility tariff data

Information for the user-selected tariff is provided by the TAP database. These data include a unique tariff ID, and the information required to define the TOU periods for this tariff. TOU tariffs are currently available for selected utilities around the United States. Due to the complex geographic variation of some utilities in California, we developed a correspondence table to help users select their utility tariff. Within California, we generated a table that matches each 5-digit ZIP code to a specific utility service territory. This information is available at: http://hes.lbl.gov/hes/CalUtilZips.doc

5.2.3.3 Non-HVAC hourly loads

For non-HVAC end-uses, we have pre-calculated a set of fixed (i.e. household independent) end-use load shapes. The monthly allocation factor (Table 32), distributes annual energy consumption across the calendar year. This monthly energy is transformed into two 24-hour profiles using the load factors in the "2-day-type" loadshapes (for each month, average weekday and average weekend), derived from the California Energy Commission forecasting model (Appendix D). These load shape data were developed by Primen Consulting, a subcontractor to ICF, under contract to CEC and have been processed to better integrate with our data processing system, based on the same underlying load data. These load shapes are not user-variable. Finally using the 2005 calendar year to specify the appropriate day type, an 8760-hour profile is created for each end use.

Table 32. Normalized Monthly Load Factors for CEC Load Schedules

Appliance Category	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water heater	0.102	0.092	0.088	0.085	0.088	0.066	0.068	0.068	0.066	0.088	0.085	0.102
Refrigerator	0.071	0.064	0.092	0.089	0.092	0.090	0.093	0.093	0.090	0.079	0.076	0.071
Freezer	0.071	0.064	0.092	0.089	0.092	0.090	0.093	0.093	0.090	0.079	0.076	0.071
Cooking Appliances	0.093	0.084	0.084	0.081	0.084	0.073	0.076	0.076	0.073	0.092	0.089	0.093
Dishwasher	0.093	0.084	0.084	0.081	0.084	0.073	0.076	0.076	0.073	0.092	0.089	0.093
Clothes washer	0.086	0.077	0.087	0.084	0.087	0.082	0.085	0.085	0.082	0.082	0.079	0.086
Clothes dryer	0.098	0.088	0.086	0.083	0.086	0.072	0.075	0.075	0.072	0.086	0.083	0.098
Home Entertainment Appliances	0.097	0.087	0.082	0.080	0.082	0.082	0.085	0.085	0.082	0.074	0.071	0.097
Waterbed heater	0.108	0.097	0.077	0.075	0.077	0.075	0.077	0.077	0.075	0.077	0.075	0.108
Spa heater	0.071	0.064	0.092	0.089	0.092	0.090	0.093	0.093	0.090	0.079	0.076	0.071
Spa pump	0.078	0.071	0.078	0.075	0.078	0.095	0.098	0.098	0.095	0.078	0.075	0.078
Pool heater	0.081	0.073	0.081	0.079	0.081	0.090	0.093	0.093	0.090	0.081	0.079	0.081
Pool pump	0.081	0.073	0.081	0.079	0.081	0.090	0.093	0.093	0.090	0.081	0.079	0.081
Miscellaneous Appliances	0.098	0.089	0.086	0.083	0.086	0.073	0.075	0.075	0.073	0.083	0.080	0.098

5.2.3.4 Heating and Cooling Hourly Loads

For each household, DOE-2 generates annual, 8760 hourly loads. These loads are reported as several components (variables), which must be aggregated with the individual 8760 “non-HVAC” profiles to create the whole-house load. Some of the variables returned in the DOE-2 reports apply to non-electric consumption, which are ignored for the calculations described here.

5.2.3.5 TOU Mask

TOU tariffs assign each hour of each day to one of several periods. The current implementation of TAP allows three periods: peak, off-peak and shoulder. Different tariffs apply in each period.

A TOU mask is a set of three time series **P(j), F(j)** and **S(j)**, **j=1,8760**.

By definition:

- **P(j) = 1** if hour **j** occurs during a peak period, **P(j) = 0** otherwise.

- **F(j) = 1** if hour **j** occurs during an off-peak period, **F(j) = 0** otherwise.
- **S(j) = 1** if hour **j** occurs during a shoulder period, **S(j) = 0** otherwise.
- **P(j) + F(j) + S(j) = 1** for all **j.**

5.2.3.6 Load Aggregator

The core of the load processing is called the "Load Aggregator." The load aggregator is a Fortran program that runs on the web application server. Input data for the load aggregator are stored in a run-specific temporary directory on the web application server. The aggregator processing steps are shown in Figure 13. Two versions of the load aggregator are used – one for TOU tariffs and another for standard (one-period) block-rate tariffs. An auxiliary program provides the ability to dynamically generate TOU mask files, if a cached version does not exist on the web application server. These mask files are generated from a summary description of the tariff TOU periods, retrieved in real-time from the TAP server using the SOAP protocol. SOAP (Simple Objects Access Protocol) is a process that provides a way for applications running on different operating systems, with different technologies and programming languages to communicate over the internet.

5.2.4 Input Values to TAP Utility Tariff Web Service

The output of the Load Aggregator are six numbers per calendar month, corresponding to the total energy consumption and maximum demand in each of three time periods (peak, off-peak and shoulder). These values, along with identification of the chosen tariff, are sent to the TAP bill calculator using a SOAP interface. Bills are calculated for the specific tariff using the TAP bill calculation web service. This terminology is drawn from TOU tariffs, but essentially the same method applies to standard tariffs with only one time period. For non-TOU tariffs all the energy is allocated to the "off-peak" bin. Time periods are defined differently for each utility or in some cases for each tariff.

5.2.5 Bill Allocation to Specific End-Uses

Once the monthly electricity bill has been returned by the TAP web service, the monthly average (not marginal) electricity bills by end-use are estimated by allocating the whole-house monthly bill according to the relative monthly energy consumption for each end-use using Equation 37.

Equation 37

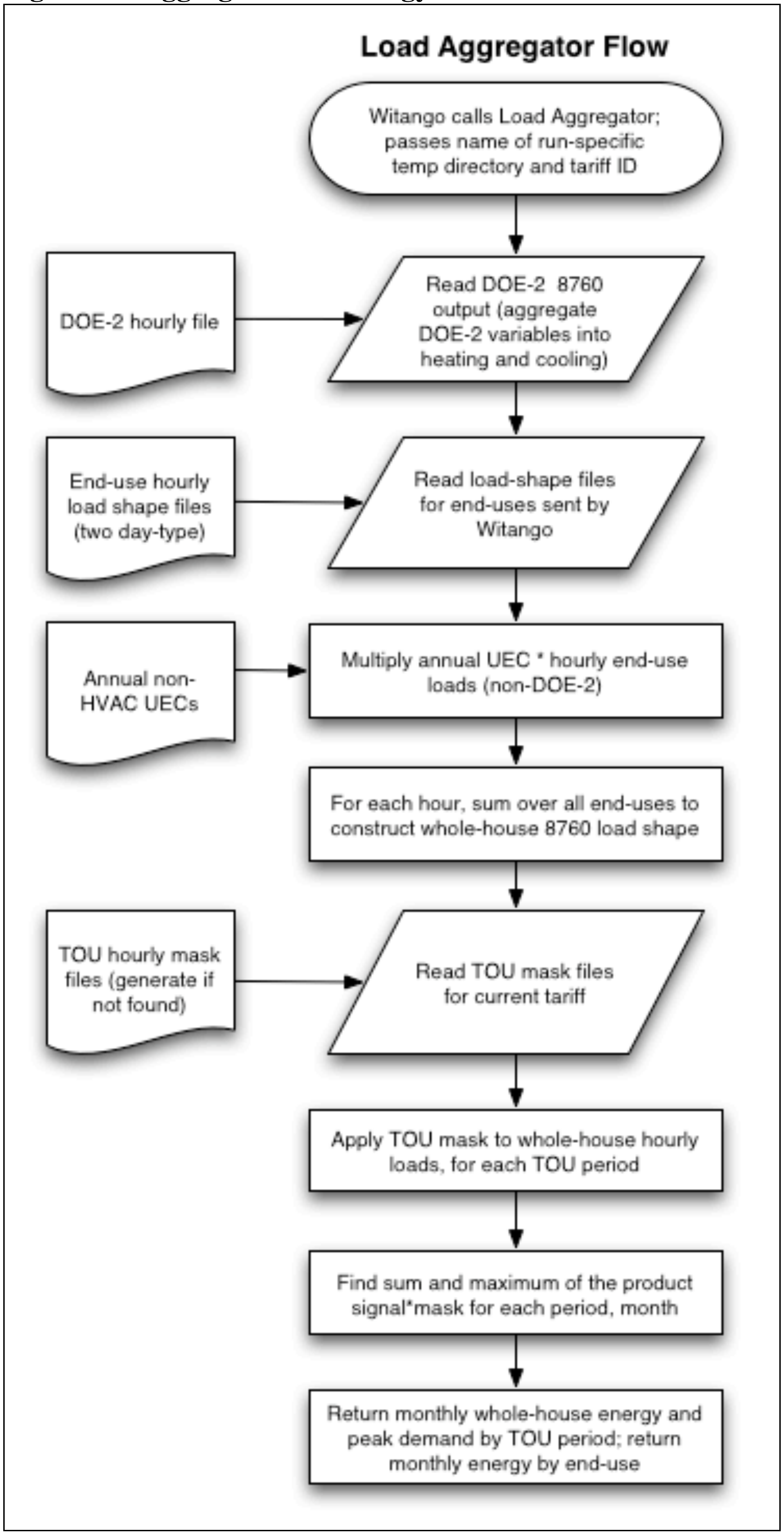
$$monthlyBill_{enduse} = monthlyBill_{house} * \left(\frac{annualEnergy_{enduse} * monthlyFactor_{enduse}}{monthlyEnergy_{house}} \right)$$

where

$monthlyBill_{house}$ = monthly bill returned by TAP service
$monthlyFactor_{endues}$ = monthly allocation factor derived from CEC loadshapes
$annualEnergy_{endues}$ = calculated energy for endues
$monthlyEnergy_{house}$ = monthly energy consumption returned by Load Aggregator

The resulting energy bills are used to show both the main results page, and additional report, the monthly electricity bill report, and where appropriate the TOU report, where monthly energy is displayed according to TOU bin.

Figure 13. Aggregation of Energy into TOU Bins.



Start the Aggregator process

Import DOE-2 hourly output files (the hourly heating and cooling energy consumption).

Import non-HVAC hourly load shapes (derived from California Energy Commission load shape data).

Create hourly consumption profile for non-HVAC appliances using hourly load shapes

Combine all hourly consumption files into a single whole-house hourly consumption profile.

The TOU mask file indicates the "bin" (peak, off-peak or shoulder) to which each hour's energy consumption should be allocated. If the tariff has been used prior to this calculation, a TOU hourly will exist. If not, a mask is generated using details about the tariffs rate structure.

After applying the TOU mask, sum consumption in each bin, and find the maximum demand for the house.

Results from the process are returned for use in calculating energy bill.

5.2.6 TAP Web Service

As noted above, the TAP database was created expressly for the purpose of storing utility tariff data and calculating customer bills using data from these tariffs. The web service consists of several functions, described below. These functions provide a client with enough data to ultimately select and generate a monthly bill from any tariff in the TAP database. In order to integrate this capability with the current HES web site, a web service interface was added to the TAP database. This web service was implemented using the SOAP protocol.

Three groups of methods provide an interface with the TAP database. These include: Utility Listing methods to allow the user to select his or her utility, Tariff Listing methods to further select individual rate schedules, and Bill Calculation methods to determine utility bills based on load data.

- Utility Listing Methods – Accept state or ZIP code data, and return corresponding utility names and codes
- Tariff Listing Methods – Return a list of available tariffs for a particular utility
- Bill Calculation Methods – Return consumption, demand and fixed charges from consumption values generated by load processing module

A complete description of the SOAP schema and sample XML syntax can be found on-line at http://hes.lbl.gov/hes/ImplementingTAP.pdf

5.2.6.1 OnTAP SOAP Server Interface Description

The OnTAP server accepts HTTP POST request in the form of well formed XML. These requested are then directed to a specific public function of the OnTAP server. Specific functions are declared in the request XML. Requests that are do not call a registered method will return the WSDL description of the OnTAP class.

The OnTAP class' public methods function as follows:

5.2.6.2 Utility Listing Methods

The following methods accept different inputs and return the same utility information output as a XML document. This document is in the form of an array of string indexed arrays values (a 2 dimentional hash table).

- *doGetUtilityListByState*: This accepts either a state's full name or it's 2 letter abbreviation as a string.
- *doGetUtilityListByZip*: This accepts a 5 digit zip code as an integer.

  The XML returned contains the following values:

- **name**: the name of the utility
- **util_id**: the internal TAP utility id
- **state**: the state in which the utility is headquartered
- **country**: the country in which the utility operates

- **url**: a link to the utility's home page within TAP
- **eia_code**: a unique code given to each utility in the United States by the E.I.A.

The key value returned for each utility is util_id, which can then used to run the tariff Listing Methods.

5.2.6.3 Tariff Listing Methods

doGetUtilityTariffs: This accept one value: util_id as a string. The XML returned contains the following values:

- **util_id**: the internal TAP utility id
- **tariff_id**: the internal TAP tariff id
- **schedule**: the name of the tariff as named by the utility
- **state**: the state for which the tariff is for
- **market**: the commercial market for which the tariff serves
- **service**: the service classification of the that the tariff delivers
- **commodity**: the commodity that the tariff covers
- **TOU**: is the tariff time-of –use or not
- **minDemand**: the minimum demand required by the customer to use the tariff as defined by the utility
- **maxDemand**: the maximum demand allowed by the customer as defined by the utility
- **url**: a link the to the tariff's description page within TAP

The key value returned for each utility is tariff_id, this is used to run the Bill Calculation Methods.

5.2.6.4 Tariff Description Methods:

doGetTOU: Returns specific time-of-use information for the tariff `$tariff_id`. This accepts 1 value: tariff_id as an integer. It returns the Time-of-use data for tariff_id as follows: An array with items for each month of the year is returned. Each item contains the following.

- **monthName**: Is the name of a calendar month
- **peakDays**: Is an array of the days of the week for which the time-of-use period apply
- **hourEnding_01 … hourEnding_24**: Is the time-of-use billing period, each of can have a value can of: onPeak, offPeak, or shoulder.

5.2.6.5 Bill Calculation Methods:

doGetMonthlyBill: This accepts 8 values, all of them integers: tariff_id, onPeakDemand, onPeakConsumption, shoulderDemand, shoulderConsumption, offPeakDemand, offPeakConsumption, and month. It returns bill information contained in a string indexed array. The bill data returned is the same for both time-of-use tariffs and standard block rate types. The values returned are as follows:

- **totalCharges**: the sum of all charges
- **consumptionTotal**: the sum of all consumption charges
- **demandTotal**: the sum of all demand charges
- **fixedTotal**: the sum of all fixed chages
- **offPeakConsumptionTotal**: the sum of all consumption charges that occur during the off-peak time-of-use period.
- **offPeakDemandTotal**: the sum of all demand charges that occur during the off-peak time-of-use period.

- **onPeakConsumptionTotal**: the sum of all consumption charges that occur during the peak time-of-use period.
- **onPeakDemandTotal**: the sum of all demand charges that occur during the peak time-of-use period.
- **shoulderConsumptionTotal**: the sum of all consumption charges that occur during the shoulder or partial-peak time-of-use period.
- **shoulderDemandTotal**: the sum of all demand charges that occur during the shoulder or partial-peak time-of-use period .
- **annualConsumptionTotal**: the sum of all other consumption charges that occur regardless of the time-of-use period.
- **annualDemandTotal**: the sum of all other demand charges that occur regardless of the time-of-use period.

DoGetYearlyBill: Is a wrapper for the doGetMonthlyBill method, it allows clients to sent a complete year's worth of inputs and return a complete year's worth of bills. It accepts and returns a 12-element array (one for each month) of doGetMonthlyBill inputs and outputs.

6. User Reports

6.1 Summary by End Use

The energy consumed by devices in each of the major end-use categories (Heating, Cooling, Water Heating, Major Appliances, Small Appliances and Lighting) is summed by utility fuel (Equation 38) and presented in three forms, as an annual bill, as energy consumed and as pollution, in the form of carbon emissions (as CO_2). Some end-uses have subdivisions that can also be presented to the user. This information is shown when the user has changed the inputs in the more detailed area. For example, if the user doesn't customize the inputs for Lighting, only one number, Annual Lighting Consumption will be shown. If the user gives general information about the lighting in each room of their house, then the information shown will include summaries of consumption at the room level. If a user goes further to specify actual fixtures in the various rooms, the summary report for Lighting will show this fixture level, as well as summed consumption by room and for the entire house. For a list of the devices in each end-use, see the associated calculation section above.

$$UEC_{e,f} = \sum_{d=1}^{n} UEC_{e,d,f}$$ **Equation 38**

where

UEC = Energy consumption
d = Device
e = End-Use category (e.g heating, cooling etc.)
f = fuel in utility units (kWh, therms, $\text{gallons}_{\text{lpg, fuel oil}}$)

To arrive at the final bill and pollution for each end use, the energy consumption for each fuel is multiplied by the price and emissions factor for each fuel (Equations 39 and 40). These values are summed across all fuels to get the end use bill and pollution.

$$bill_e = \sum_{f=1}^{n} (UEC_{e,f} * p_f)$$ **Equation 39**

where

UEC = Energy consumption
bill = annual bill (dollars)
e = End-Use category
p = energy price (dollars)
f = fuel in utility units (kWh, therms, $\text{gallons}_{\text{lpg, fuel oil}}$)

$$pollution_e = \sum_{f=1}^{n}(UEC_{e,f} * c_f) \qquad \textbf{Equation 40}$$

where

UEC = Energy consumption
pollution = annual pollution emissions (lbs/C)
e = End-Use category
c = emissions factor (lbs/C)
f = fuel in utility units (kWh, therms, $\text{gallons}_{\text{lpg, fuel oil}}$)

Total house values for energy, bill and pollution emissions are calculated by summing across end uses. These resulting values are displayed to the user on the results pages shown in Technical Specification of the Home Energy Saver website(Appendix D).

6.2 Carbon Emissions Factors

To arrive at the carbon emissions (as CO_2) for energy consumed in the user's house, we multiply the annual energy for each fuel type by the emissions factor for the respective fuel. Table 34 contains the state level emissions factors for electricity while Table 33 has the emissions factors for all other fuels. Electricity emissions factors are from U.S. EPA's eGRID (Emissions & Generation Resource Integrated Database), which contains emissions and resource mix data for virtually every power plant and company that generates electricity in the United States (US EPA 2003). Natural gas and fuel oil emission factors are derived from U.S. DOE (1994), while the LPG emission factor is from U.S. DOE (1996).

Table 33. Direct Carbon Emissions (as CO_2) from Residential Fuel Combustion

Fuel	lb. CO2/MBtu
Natural gas	116.83
LPG	137.26
Distillate oil	161.08

Table 34. State Level Electricity Carbon Emissions Factors (as CO_2)

State	Emissions (lb CO_2 / kWh)		State	Emissions (lb CO_2 / kWh)
Alabama	1.446297		Nebraska	1.546841
Alaska	1.291326		Nevada	1.552132
Arizona	1.175167		New Hampshire	0.708633
Arkansas	1.453267		New Jersey	0.732554
California	0.633056		New Mexico	2.137023
Colorado	2.013769		New York	0.979677
Connecticut	0.738835		North Carolina	1.292849
Delaware	1.951508		North Dakota	2.393321
Florida	1.420419		Ohio	1.844002
Georgia	1.413873		Oklahoma	1.835885
Guam	2.066944		Oregon	0.329269
Hawaii	1.716643		Pennsylvania	2.066944
Idaho	0.093223		Puerto Rico	1.234101
Illinois	1.109446		Rhode Island	2.066944
Indiana	2.152954		South Carolina	1.001701
Iowa	1.971971		South Dakota	0.893246
Kansas	1.86854		Tennessee	0.832723
Kentucky	2.228804		Texas	1.368518
Louisiana	1.386282		Utah	1.468507
Maine	0.655091		Vermont	2.095467
Maryland	2.066944		Virginia	0.056934
Massachusetts	1.372829		Virgin Islands	1.231575
Michigan	1.293151		Washington	2.066944
Minnesota	1.564727		Washington DC	0.287486
Mississippi	1.640076		West Virginia	2.656955
Missouri	1.316731		Wisconsin	2.027326
Montana	1.979393		Wyoming	1.760653

References

Association of Home Appliance Manufacturers (AHAM). "ANSI/AHAM RAC-1-1982: American National Standard - Room Air Conditioners." Washington, DC. (www.aham.org).

Air Conditioning and Refrigeration Institute (ARI). 1995. *ARI Directory of Certified Unitary Products*. Electronic Version, July,

Air Conditioning and Refrigeration Institute (ARI). 2003. *ARI Statistical Profile*. April 25.

Apte, J.S. 2004 "Residential windows, Greenhouse Gas Emissions and the Potential of Emerging Window technologies", Baccalaureate thesis, Brown University. May.

ASHRAE. 1997a. *Method of Test For Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems (ASHRAE Standard 152P). Proposed*. Atlanta, GA: American Society of Heating, Refrigeration, and Air-Conditioning Engineers

ASHRAE. 1997b. ASHRAE Handbook: 1997 Fundamentals. Atlanta, GA: American Society of Heating, Refrigeration, and Air-Conditioning Engineers.

Association of Home Appliance Manufacturers (AHAM). 1996. *Energy Efficiency and Consumption Trends. var. products*. June-October. Updated information accessed at http://www.aham.org/mfrs/stats/, July 1998.

Association of Home Appliance Manufacturers (AHAM). 2003. *AHAM Fact Book 2003*.

Biermayer, Peter. 1996. *Personal Communication:* "Clothes dryer and Dishwasher load rates based on household occupants; originally from Proctor and Gamble study" Berkeley, CA: Lawrence Berkeley National Laboratory. email.

Birdsall, B., W.F. Buhl, K.L. Ellington, A.E. Erdem, and F.C. Winkelmann. 1990. *Overview of the DOE-2 Building Energy Analysis Program, Version 2.1D*. Lawrence Berkeley National Laboratory. LBL-19735, Rev. 1.

California Energy Commission (CEC). 1998. *On-line Database of CEC-certified Products*. Available from the World Wide Web: http://www.energy.ca.gov/efficiency/appliances/.

EIA. 1995. *1993 Residential Energy Consumption Survey (RECS): Public-Use Microdata*. U.S. Department of Energy, Energy Information Administration.

GAMA. 1996. Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment. Gas Appliance Manufacturers Association, Inc. October.

GAMA. 2002. Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment. Gas Appliance Manufacturers Association, Inc.

GAMA. 2003. Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment. Gas Appliance Manufacturers Association, Inc.

Greenberg, Steve. 2005. Personal communication. Lawrence Berkeley National Laboratory. May 18.

Honeywell. 1994. *Honeywell Corporation Thermostat Energy Savings Estimator*.

Huang, Y.J., R. Ritschard, J. Bull, S. Byrne, I. Turiel, D. Wilson, C. Hsui, and D. Foley. 1987. *Methodology and Assumptions for Evaluating Heating and Cooling Energy Requirements in New Single-Family Residential Buildings. Technical Support Document for the PEAR Microcomputer Program*. Lawrence Berkeley Laboratory. LBL-19128. January.

Huang, Joe, James Hanford, and Fuqiang Yang. 1999. Residential Heating and Cooling Loads Component Analysis. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-44636. November.

Jennings, J., M. Moezzi, R. Brown, E. Mills, R. Sardinsky, B. Heckendorn, D. Lerman, L. Tribwell. 1997. "Residential Lighting: The Data to Date." Journal of the Illuminating Engineering Society. Vol. 26, No. 2. Summer 1997. also LBL-35484, March, 1996.

Jump, David A., Iain S. Walker, and Mark P. Modera. 1996. *Field Measurements of Efficiency and Duct Retrofit Effectiveness in Residential Forced Air Distribution Systems*. Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings. Washington DC: American Council for an Energy Efficient Economy.

Koomey, Jonathan, Celina Atkinson, Alan Meier, James E. McMahon, Stan Boghosian, Barbara Atkinson, Isaac Turiel, Mark D. Levine, Bruce Nordman, and Peter Chan. 1991. *The Potential for Electricity Efficiency Improvements in the U.S. Residential Sector*. Lawrence Berkeley Laboratory. LBL-30477. July.

Koomey, J.G., C. Dunham, J.D. Lutz. 1994. *The Effect of Efficiency Standards on Water Use and Water Heating Energy Use in the U.S.: A Detailed End-use Treatment*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-35475. May.

Koomey, Jonathan. 1997. Personal communication. "End-use emission factors for residential fuel-fired end-uses." Lawrence Berkeley National Laboratory.

L'Ecuyer, Michael, Cathy Zoi, and John S. Hoffman. 1993. *Space Conditioning: The Next Frontier (The Potential of Advanced Residential Space Conditioning Technologies for Reducing Pollution and Saving Consumers Money)*. Office of Air and Radiation, US Environmental Protection Agency. EPA 430-R-93-004. April.

Lutz, James D. Xiaomin Liu, James E. McMahon, Camilla Dunham, Leslie J. Shown and Quandra T. McGrue. 1996. *Modeling Patterns of Hot Water Use in Households*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-37805. November.

Lutz, James D. personal communication, 1998-2000.

Marion, W., and K. Urban. 1995. *User's Manual for TMY2s (Typical Meteorological Years): Derived from the 1961-1990 National Solar Radiation Data Base*. Golden, CO: National Renewable Energy Laboratory. Available from World Wide Web: (http://rredc.nrel.gov/solar/pubs/tmy2/)

Matson, Nance. June 23, 1998. *Personal Communication:* "LBNL Residential Air Leakage Database Summary Results." Berkeley, CA: Lawrence Berkeley National Laboratory.

Mayer, Peter, William DeOreo, Eva Opitz, Jack Kiefer, William Davis, Benedykt Dziegielewski, and John Olaf Nelson. 1999. *Residential End Uses of Water*. Denver, CO: American Water Works Association Research Foundation. AWWARF # 90781

Mills, E. 1997. "The Home Energy Saver: Interactive Energy Information and Calculations on the Web." Center for Building Science News 16(4):1-2. LBL/PUB-731. Available on-line at http://eetd.lbl.gov/newsletter/CBS_NL/NL16/HES.html.

Mills, E. 2002. *Review and Comparison of Web- and Disk-based Tools for Residential Energy Analysis*. LBNL-50950. Available on-line at http://eetd.lbl.gov/emills/PUBS/SoftwareReview.html

Modera, Mark. 1998. Personal Communication. *Savings Potential from Duct Sealing*. Lawrence Berkeley National Laboratory.

Nordman, Bruce, and Jim McMahon. 2004. *Developing and Testing Low Power Mode Measurement Methods* [plus additional unpublished data]. Sacramento, CA: California Energy Commission. P500-04-057. September.

ORNL. 1997. *Climate Data Used to Develop DOE Recommended Insulation Levels* [electronic file]. Oak Ridge National Laboratory, August 22, 1997 [cited August 12 1998]. Available on-line at: (http://www.ornl.gov/roofs+walls/insulation/data/climate)

Pacific Gas & Electric (PG&E) Smarter Energy Line. 1995. *Spot the Big Spenders: Residential Energy Consumption*. CA. December.

Ritschard, Ron L., Jim W. Hanford, and A. Osman Sezgen. 1992. Topical Report: Single-Family Heating and Cooling Requirements: Assumptions, Methods, and Summary Results. Lawrence Berkeley Laboratory, for the Gas Research Institute. LBL-30377, GRI-91/0236. March.

Ross, J.P. and Alan Meier. 2000. *"Whole-House Measurements of Standby Power Consumption"*. In The Second International Conference on Energy Efficiency in Household Appliances; Naples, Italy; September 27-29, 2000. LBNL-45967.

Sanchez, Marla C. October, 1996. *Personal Communication:* "Priority Table UECs" Berkeley, CA: Lawrence Berkeley National Laboratory. spreadsheet

Sanchez, Marla C. 1997. *Miscellaneous Electricity Use in U.S. Residences*. M.S. Thesis, University of California, Berkeley.

Sanchez, Marla C., Jonathan G. Koomey, Mithra M. Moezzi, Alan K. Meier, and Wolfgang Huber. 1998. *Miscellaneous Electricity Use in the U.S. Residential Sector*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-40295. April.

Sherman, Max, and Nance Matson. 1997. *Residential Ventilation and Energy Characteristics*. ASHRAE Transactions (American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA). vol. 103, no. 1 (also LBNL-39036). pp. 717-730.

Stovall, Therese K. 1997. *Supporting Documentation for the 1997 Revision to the DOE Insulation Fact Sheet*. Oak Ridge National Laboratory. ORNL-6907. August 22.

Tribwell, Lyle S. and David I. Lerman. 1996. "Baseline Residential Lighting Energy Use Study." Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings. p. 3.153

TNC. 2001. "Nature Conservancy Ecoregions of the United States." The Nature Conservancy. (ftp://ftp.tnc.org/data/national/usa/tnc_us_eco2001.zip). Accessed March 2005.

U.S. Census Bureau. 2004. "ZIP Code Tabulation Area (ZCTA) for Census 2000." (http://www.census.gov/geo/ZCTA/zcta.html). Accessed March 2005.

US DOE. 1990. *Technical Support Document: Energy Conservation Standards for Consumer Products: Dishwashers, Clothes Washers, and Clothes Dryers*. U.S. Department of Energy, Assistant Secretary, Conservation and Renewable Energy, Building Equipment Division. DOE/CE-0299P. December.

US DOE. 1993. *Technical Support Document: Energy Conservation Standards for Consumer Products: Room Air Conditioners, Water Heaters, Direct Heating Equipment, Mobile Home Furnaces, Kitchen Ranges and Ovens, Pool Heaters, Fluorescent Lamp Ballasts, and Television Sets*. U.S. Department of Energy, Assistant Secretary, Energy Efficiency and Renewable Energy, Building Equipment Division. Volume 3: Water Heaters, Pool Heaters, Direct Heating Equipment, Mobile Home Furnaces; DOE/EE-0009. November.

US DOE. 1994. *"Emissions of Greenhouse Gases in the United States, 1987-1992"*. DOE/EIA-0573. October.

US DOE. 1996. *"Emissions of Greenhouse Gases in the United States, 1995"*. DOE/EIA-0573(95). October.

US DOE. 1995. *Technical Support Document: Energy Efficiency Standards for Consumer Products: Refrigerators, Refrigerator-Freezers, & Freezers*. U.S. Department of Energy, Assistant Secretary, Energy Efficiency and Renewable Energy, Office of Codes and Standards. DOE/EE-0064. July.

US DOE. 1995a. *1993 Residential Energy Consumption Survey (RECS): Public-Use Microdata*. EIA, Energy Information Administration, U.S. Department of Energy, Washington, DC.

US DOE. 1996. Electric Power Annual 1995. Energy Information Administration. DOE/EIA-0348(95)/1,2. July, December.

US DOE. 1997. *State Energy Price and Expenditure Report 1995*. Washington, DC: Energy Information Administration, U.S. Department of Energy. DOE/EIA-0376(95). July.

US DOE. 1998a. *Form EIA-176: Annual Report of Natural and Supplemental Gas Supply and Disposition*. Energy Information Administration, U.S. Department of Energy [cited 14 January 1999]. Available on-line at: (ftp://ftp.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/historical/1997/pdf/table_024.pdf).

US DOE. 1998b. *Form EIA-826: Monthly Electric Utility Sales and Revenue Report with State Distributions*. Energy Information Administration, U.S. Department of Energy [cited 23 June 1998]. Available on-line at: (http://www.eia.doe.gov/cneaf/electricity/epm/html/table55.html).

US DOE. 2000a. *Technical Support Document: Energy Efficiency Standards for Consumer Products: Clothes Washers*. Washington, DC: U.S. Department of Energy, Assistant Secretary, Energy Efficiency and Renewable Energy, Office of Building Research and Standards. October. Available online at: (http://www.eren.doe.gov/buildings/codes_standards/reports/cwtsd/index.html)

US DOE. 2000b. *State Energy Data 2000 Price and Expenditure Data*. Washington, DC: U.S. Department of Energy, Energy Information Administration. Available on-line at: http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/sum_pr_all.pdf) accessed 10/13/03.

US DOE. 2000c. *Technical Support Document: Energy Efficiency Standards for Consumer Products: Residential Water Heaters*. Washington, DC: U.S. Department of Energy, Assistant Secretary, Energy Efficiency and Renewable Energy, Office of Building

Research and Standards. December. Available from World Wide Web: (http://www.eere.energy.gov/buildings/appliance_standards/residential/waterheat_0300_r.html)

US DOE. 2004. *2001 Residential Energy Consumption Survey (RECS): Public-Use Microdata*. EIA, Energy Information Administration, U.S. Department of Energy, Washington, DC. (http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html)

US DOE. 2004a. *Historical 1990 through Current Month Retail Sales, Revenues, and Average Revenue per Kilowatthour by State and by Sector taken from Electric Power Monthly,* Washington, DC: U.S. Department of Energy, Energy Information Administration. Available on-line at: http://www.eia.doe.gov/cneaf/electricity/page/at_a_glance/sales_tabs.html) accessed on 06/24/05.

US DOE. 2004b. *Historical 1973 through Current Natural Gas Residential Price by State taken from Natural Gas Monthly*. Washington, DC: U.S. Department of Energy, Energy Information Administration. Available on-line at: http://tonto.eia.doe.gov/dnav/ng/xls/ng_sum_lsum_a_EPG0_PRS_DMcf_a.xls) accessed 06/24/05.

U.S. EPA. 2003. "eGRID 2002, Version 2.01." Washington, DC: U.S. Environmental Protection Agency. (http://www.epa.gov/cleanenergy/egrid/).

Warner, Jeffrey L. 2005. *The Use of DOE-2 in the Home Energy Saver*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-51948.

Wateright. 2003. *Wateright Advisory: Energy Use/Costs for Pumping* [web page]. Center for Irrigation Technology, CSU Fresno, November 2003 [cited May 18 2005]. Available from World Wide Web: (http://www.wateright.org/site2/advisories/energy.asp)

Wenzel, Tom P., Jonathan G. Koomey, Gregory J. Rosenquist, Marla C. Sanchez, and James W. Hanford. 1997. *Energy Data Sourcebook for the U.S. Residential Sector*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-40297. September.

Winkelmann, F.C., B.E. Birdsall, W.F. Buhl, K.L. Ellington, A.E. Erdem, J.J. Hirsch, and S. Gates. 1993. DOE-2 Supplement, Version 2.1E. LBNL-34947. Berkeley, California: Lawrence Berkeley National Laboratory.

Zogg, Robert A., and Deborah L. Alberino. 1998. *Electricity Consumption by Small End Uses in Residential Buildings*. Cambridge, MA: Arthur D. Little, Inc. Reference 34732-00. August 20. Available on-line at: (http://www.eren.doe.gov/buildings/documents/pdfs/enduses.pdf

Appendix A. Default House Characteristics

Table A-1. Characteristics Based on Climate Zone

Climate zone	1	2	3	4	5	6	7	8	9	10
Year house was built	1956	1958	1960	No Zone 4	1951	1962	1968	1972	1975	1973
Number of stories	2	2	2		2	1	2	1	1	1
Heating equipment	Oil Boiler	Gas Furnace	Gas Furnace		Gas Furnace	Gas Furnace	Gas Furnace	Heat Pump	Electric Furnace	Heat Pump
Cooling equipment	None	Central A/C	Central A/C		Central A/C	Central A/C	Central A/C	Heat Pump	Central A/C	Heat Pump
Water heater fuel	Oil	Gas	Gas		Gas	Gas	Gas	Electricity	Electricity	Electricity
Adult at home during day	0	1	1		0	1	0	0	1	1
Pay for water heating fuel	1	1	1		1	1	1	1	1	1
Number of ceiling fans.	1	2	2		2	2	2	3	4	3
Year refrigerator was purchased	1993	1996	1996		1995	1996	1995	1996	1995	1997
Own a dishwasher	Yes	Yes	Yes		No	Yes	Yes	Yes	Yes	No
Own a clothes washer	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Foundation Type	Conditioned Basement	Conditioned Basement	Conditioned Basement		Conditioned Basement	Conditioned Basement	Conditioned Basement	Vented Crawlspace	Slab	Vented Crawlspace
Clothes dryer fuel	Electricity	Electricity	Electricity		Electricity	Electricity	Electricity	Electricity	Electricity	Electricity
Stove fuel	Electricity	Electricity	Electricity		Electricity	Electricity	Electricity	Electricity	Electricity	Electricity
Oven fuel	Electricity	Electricity	Electricity		Electricity	Electricity	Electricity	Electricity	Electricity	Electricity

Climate zone	11	12	13	14	15	16	17	18	19	20
Year house was built	1968	1963	1969	1959	1971	1963	1970	1972	1966	1963
Number of stories	1	1	1	1	2	1	1	1	1	1
Heating equipment	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace	Gas Furnace
Cooling equipment	Central A/C	Central A/C	Central A/C	None	None	None	None	None	None	None
Water heater fuel	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas
Adult at home during day	1	1	1	1	1	1	1	1	1	1
Pay for water heating fuel	1	1	1	1	1	1	1	1	1	1
Number of ceiling fans.	3	3	3	1	1	3	3	1	1	1
Year refrigerator was purchased	1997	1995	1996	1997	1996	1995	1996	1992	1994	1997
Own a dishwasher	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Own a clothes washer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Foundation Type	Vented Crawlspace	Slab	Slab	Conditioned Basement	Conditioned Basement	Slab	Slab	Vented Crawlspace	Slab	Slab
Clothes dryer fuel	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity	Natural Gas
Stove fuel	Electricity	Electricity	Natural Gas	Electricity	Electricity	Natural Gas	Electricity	Electricity	Natural Gas	Natural Gas
Oven fuel	Electricity	Electricity	Natural Gas	Electricity	Electricity	Natural Gas	Electricity	Electricity	Electricity	Natural Gas

Table A-2 National Default Housing Characteristics

Default Characteristic	Value	Unit
Number of occupants aged 0 to 5	0	person(s)
Number of occupants aged 6 to 13	1	person(s)
Number of occupants aged 14 to 64	2	person(s)
Number of occupants aged 65 and older	0	person(s)
Thermostat setting of water heater	130	deg. F.
Location of water heater	garage	
Pay for water heating fuel	Yes	
Dishwasher loads washed	4	loads/week
House has clothes washer	Yes	
Clothes washer loads washed in hot wash / warm rinse	2	loads/week
Clothes washer loads washed in hot wash / cold rinse	0	loads/week
Clothes washer loads washed in warm wash / warm rinse	3	loads/week
Clothes washer loads washed in warm wash / cold rinse	2	loads/week
Clothes washer loads washed in cold wash / cold rinse	0	loads/week
First refrigerator model	General	
First refrigerator year	1986	
First refrigerator size	17	cubic feet
Second refrigerator model	None	
Second refrigerator year	0	
Second refrigerator size	0	cubic feet
Third refrigerator model	None	
Third refrigerator year	0	
Third refrigerator size	0	cubic feet
First freezer model	None	
First freezer year	0	
First freezer size	0	cubic feet
Second freezer model	None	
Second freezer year	0	
Second freezer size	0	cubic feet
Clothes dryer loads washed	7	loads/week
Clothes dryer fuel	Electricity	
Stove fuel	Electricity	
Oven fuel	Electricity	
Hours stove used per week	1	hour
Hours oven used per week	2	hours
Does stove have a pilot light	No	
Does oven have a pilot light	No	
Lighting consumption in kitchen	218	kWh/year

Lighting consumption in dining room	136	kWh/year
Lighting consumption in living room	109	kWh/year
Lighting consumption in family room	77	kWh/year
Lighting consumption in master bedroom	81	kWh/year
Lighting consumption in bedroom	73	kWh/year
Lighting consumption in closet	0	kWh/year
Lighting consumption in bathroom	192	kWh/year
Lighting consumption in hall	98	kWh/year
Lighting consumption in utility room	0	kWh/year
Lighting consumption in garage	71	kWh/year
Lighting consumption in outdoor fixtures	231	kWh/year
Lighting consumption in other rooms	0	kWh/year
Number of lighting fixtures in kitchen	2	fixtures
Number of lighting fixtures in dining room	1	fixtures
Number of lighting fixtures in living room	3	fixtures
Number of lighting fixtures in family room	1	fixtures
Number of lighting fixtures in master bedroom	2	fixtures
Number of lighting fixtures in bedroom	2	fixtures
Number of lighting fixtures in closet	0	fixtures
Number of lighting fixtures in bathroom	2	fixtures
Number of lighting fixtures in hall	2	fixtures
Number of lighting fixtures in utility room	0	fixtures
Number of lighting fixtures in garage	1	fixtures
Number of lighting fixtures outdoors	2	fixtures
Number of lighting fixtures in other rooms	0	fixtures

Appendix B. Default Energy Consumption

Table B-1 Average Annual Residential End-Use Energy Consumption by Climate Zone

Climate Zone	Space Heating (Mbtu)			Electric Space Cooling (Mbtu)	Water Heating (Mbtu)			Appliances (Mbtu)		Miscellaneous Electricity (Mbtu)
	Electricity	Natural Gas	Fuel Oil		Electricity	Natural Gas	Fuel Oil	Electricity	Natural Gas	
1	0	0	84	0	0	0	30	10	2	13
2	0	64	0	5	0	20	0	10	5	14
3	0	68	0	6	0	21	0	11	5	16
5	0	58	0	5	0	17	0	11	3	13
6	0	61	0	9	0	21	0	14	2	16
7	0	59	0	8	0	18	0	11	5	16
8	10	0	0	12	9	0	0	13	2	15
9	3	1	0	19	9	0	0	13	1	18
10	19	0	0	9	11	0	0	14	0	17
11	0	51	0	12	0	21	0	15	2	16
12	0	53	0	14	0	23	0	15	4	16
13	0	26	0	22	0	22	0	14	5	17
14	0	65	0	0	0	19	0	12	1	14
15	0	73	0	0	0	21	0	12	1	15
16	1	47	0	0	0	22	0	9	7	12
17	0	25	0	0	0	17	0	12	4	13
18	0	63	0	0	0	18	0	14	2	16
19	0	31	0	0	0	17	0	8	5	12
20	0	28	0	0	0	22	0	7	9	13

Notes:

1) Source: 2001 RECS - Averages are for single-family houses with the characteristics described in Table 24.
2) All energy consumption values are presented in Mbtu in the RECS dataset. Additionally the energy consumption output from the DOE 2.1E building simulation model is also presented in Mbtu. Therefore we retain energy consumption as Mbtu, and convert to utility units (kWh, therm, etc.) for presentation to the user, using the fuel-specific conversion factors found in Table 2 above.

Appendix C. Local Climate Parameters

Table C-1. Climate Parameters for Weather Locations

State	City	Dry Bulb to Wet Bulb ratio[10]	Duct Factor[11]	Design Heating Dry Bulb Temperature (°F)	Design Cooling Dry Bulb Temperature (°F)	Total Room Air Conditioner Compressor Hours (hours/yr)	Room Air Conditioner Use (hours /day)	(days /yr)	Inlet Water Temperature (°F)
Alabama	Birmingham	1.19	0.253	20	95	997	12	83	60
Alabama	Huntsville	1.22	0.303	10	95	957	12	80	58
Alabama	Mobile	1.20	0.120	30	95	1310	12	109	65
Alabama	Montgomery	1.21	0.167	30	100	1162	14	83	62
Alaska	Adak	1.09	1	30	85	0	2	0	40
Alaska	Anchorage	1.20	0.999	0	85	16	2	8	37
Alaska	Annette	1.18	0.998	20	85	11	2	6	45
Alaska	Barrow	1.06	1	-30	85	0	2	0	9
Alaska	Bethel	1.22	0.999	-20	85	11	2	5	29
Alaska	Bettles	1.26	0.995	-30	85	36	2	18	22
Alaska	Big Delta	1.27	0.995	-30	85	32	2	16	28
Alaska	Cold Bay	1.07	1	10	85	0	2	0	39
Alaska	Fairbanks	1.30	0.990	-30	85	61	2	30	26
Alaska	Gulkana	1.27	1	-30	85	21	2	11	27
Alaska	Homer	1.12	0.999	10	85	2	2	1	36
Alaska	Juneau	1.19	0.992	10	85	12	2	6	39
Alaska	King Salmon	1.18	1.000	-20	85	9	2	4	34
Alaska	Kodiak	1.14	0.999	10	85	3	2	1	41
Alaska	Kotzebue	1.17	0.999	-30	85	5	2	2	22
Alaska	McGrath	1.23	0.995	-30	85	21	2	11	26

[10] DB/WB ratio is the ratio of dry-bulb to wet-bulb temperature at the cooling design-day conditions. It is intended as a relative indicator of a climate's humidity during the cooling season. DB/WB ratio has been rounded to 2 decimal places for the purpose of this report.
[11] For "duct factor" a value of 0 implies that heating is never needed, thus all duct losses are assigned to cooling. A value of 1 implies that cooling is never needed, thus all duct losses are assigned to heating. Duct Factor has been rounded to 3 decimal places for the purpose of this report.

Alaska	Nome	1.16	1	-20	85	2	2	1	27
Alaska	St. Paul Island	1.02	1	10	85	0	2	0	35
Alaska	Summit	1.24	0.996	-20	85	9	2	5	32
Alaska	Talkeetna	1.20	0.999	-20	85	21	2	10	33
Alaska	Yakutat	1.13	1	0	85	1	2	1	38
Arizona	Flagstaff	1.37	0.934	0	85	151	5	30	47
Arizona	Phoenix	1.50	0.057	40	110	1648	12	137	71
Arizona	Prescott	1.44	0.496	20	95	603	7	86	52
Arizona	Tucson	1.40	0.101	30	105	1447	12	121	68
Arizona	Winslow	1.56	0.387	20	95	850	5	170	55
Arizona	Yuma	1.50	0.046	50	110	2441	12	203	74
Arkansas	Fort Smith	1.27	0.262	20	100	978	13	75	59
Arkansas	Little Rock	1.24	0.249	10	100	1009	13	78	60
California	Arcata	1.11	0.997	30	85	5	2	2	50
California	Bakersfield	1.43	0.151	40	105	831	11	76	63
California	China Lake	1.57	0.151	30	110	1546	11	141	55
California	Daggett	1.49	0.105	30	110	1059	12	88	64
California	El Centro	1.45	0.049	40	110	2281	13	175	60
California	El Toro	1.30	0.279	40	95	447	10	45	60
California	Fresno	1.42	0.217	30	105	831	12	69	66
California	Long Beach	1.23	0.218	40	90	205	9	23	72
California	Los Angeles	1.16	0.356	50	85	122	9	14	60
California	Mt Shasta	1.37	0.671	20	95	417	6	70	60
California	Oakland	1.20	0.881	40	85	84	8	11	57
California	Oxnard	1.23	0.537	50	85	302	7	43	59
California	Pasadena	1.29	0.241	40	95	396	10	40	56
California	Red Bluff	1.50	0.232	30	110	1009	12	84	63
California	Riverside	1.44	0.243	30	105	793	11	72	51
California	Sacramento	1.41	0.329	40	100	724	10	72	60
California	San Diego	1.21	0.220	50	85	69	8	9	57
California	San Francisco	1.30	0.905	40	85	84	6	14	57
California	Santa Maria	1.22	0.915	30	85	19	8	2	49
California	Santa Rosa	1.39	0.404	30	100	425	10	42	53
California	Sunnyvale	1.25	0.735	40	85	150	7	21	56

Colorado	Alamosa	1.44	0.971	-10	85	204	3	68	49
Colorado	Boulder	1.42	0.659	0	95	412	6	69	43
Colorado	Colorado Springs	1.45	0.762	0	90	381	5	76	48
Colorado	Denver-Stapleton AP	1.46	0.579	0	95	627	7	90	49
Colorado	Eagle	1.43	0.959	0	90	282	5	56	40
Colorado	Grand Junction	1.48	0.499	10	95	684	6	114	50
Colorado	Pueblo	1.43	0.535	0	100	668	9	74	51
Connecticut	Bridgeport	1.14	0.588	20	90	262	4	66	51
Connecticut	Hartford	1.19	0.628	0	95	285	6	48	48
Cuba	Guantanamo Bay	1.19	0	60	95	3446	12	287	80
Delaware	Wilmington	1.14	0.485	20	90	484	11	44	52
Florida	Apalachicola	1.14	0.092	40	90	1482	11	135	68
Florida	Daytona Beach	1.18	0.060	30	95	1281	12	107	68
Florida	Jacksonville	1.17	0.098	30	95	1198	13	92	65
Florida	Key West	1.14	0.003	60	90	2879	11	262	74
Florida	Miami	1.14	0.007	50	90	2031	11	185	74
Florida	Orlando	1.21	0.043	40	95	1597	12	133	71
Florida	Tallahassee	1.15	0.130	30	95	1110	13	85	64
Florida	Tampa	1.18	0.041	40	95	1677	12	140	69
Florida	West Palm Beach	1.14	0.012	40	95	1857	13	143	73
Georgia	Athens	1.19	0.259	20	95	829	12	69	59
Georgia	Atlanta	1.18	0.278	20	95	802	12	67	58
Georgia	Augusta	1.19	0.246	20	95	1023	12	85	60
Georgia	Columbus	1.21	0.180	30	95	977	12	81	62
Georgia	Macon	1.22	0.184	20	95	1008	12	84	61
Georgia	Savannah	1.18	0.146	30	95	1093	12	91	63
Guam	Anderson AFB	1.11	0.000	60	90	3226	12	269	79
Hawaii	Ewa-Barbers Point	1.24	0.001	60	90	1876	9	208	75
Hawaii	Hilo	1.12	0	60	85	1445	10	144	74
Hawaii	Honolulu	1.19	0	60	90	2016	10	202	74
Hawaii	Kahului	1.16	0.000	60	90	1852	11	168	74
Hawaii	Lihue	1.13	0	60	85	1814	9	202	74
Hawaii	Wake Island	1.12	0	60	90	3367	12	281	79
Idaho	Lewiston	1.47	0.540	20	95	1242	6	207	52

Idaho	Pocatello	1.48	0.809	0	95	445	6	74	45
Illinois	Chicago	1.18	0.634	0	95	426	6	71	49
Illinois	Chicago-Midway	1.22	0.510	10	90	711	4	178	50
Illinois	Peoria	1.18	0.590	0	95	522	6	87	50
Illinois	Rockford	1.13	0.689	0	90	368	4	92	47
Illinois	Springfield	1.19	0.502	0	95	651	12	54	51
Indiana	Evansville	1.19	0.426	0	95	782	12	65	54
Indiana	Fort Wayne	1.17	0.661	0	90	491	4	123	48
Indiana	Indianapolis	1.18	0.556	0	95	548	12	46	50
Indiana	South Bend	1.15	0.619	10	90	413	4	103	48
Iowa	Burlington	1.20	0.509	10	95	720	6	120	50
Iowa	Des Moines	1.22	0.590	0	95	493	6	82	47
Iowa	Mason City	1.17	0.764	-10	90	374	4	94	44
Iowa	Moline	1.22	0.589	0	95	529	6	88	48
Iowa	Sioux City	1.22	0.615	0	95	527	6	88	47
Iowa	Waterloo	1.16	0.713	-10	90	402	4	101	45
Kansas	Dodge City	1.35	0.439	0	100	758	11	69	52
Kansas	Goodland	1.40	0.599	0	100	599	10	60	48
Kansas	Topeka	1.20	0.455	0	95	631	12	53	53
Kansas	Wichita	1.30	0.383	0	100	723	12	60	55
Kentucky	Covington	1.17	0.508	10	90	593	11	54	52
Kentucky	Lexington	1.20	0.499	10	90	568	10	57	53
Kentucky	Louisville	1.17	0.407	10	95	752	13	58	54
Louisiana	Baton Rouge	1.18	0.120	30	95	1253	12	104	65
Louisiana	Lake Charles	1.15	0.114	30	95	1285	13	99	65
Louisiana	New Orleans	1.16	0.104	30	95	1244	13	96	66
Louisiana	Shreveport	1.20	0.163	30	95	1113	12	93	63
Maine	Bangor	1.20	0.784	0	85	255	2	128	43
Maine	Caribou	1.14	0.944	-10	85	79	2	40	38
Maine	Portland	1.15	0.826	0	85	179	2	90	44
Marshall Islands	Kwajalein Atoll	1.12	0	60	90	3868	12	322	82
Maryland	Baltimore	1.19	0.465	10	95	588	12	49	52
Maryland	Patuxent River NAS	1.19	0.356	30	90	770	10	77	57
Massachusetts	Boston-City	1.22	0.587	20	90	393	4	98	50

Massachusetts	Boston-Logan	1.22	0.645	10	90	305	4	76	49
Massachusetts	Worcester	1.13	0.782	10	90	124	4	31	46
Michigan	Alpena	1.19	0.888	0	90	149	4	37	42
Michigan	Detroit	1.16	0.704	10	90	313	4	78	49
Michigan	Flint	1.18	0.759	0	90	230	4	57	45
Michigan	Grand Rapids	1.18	0.739	0	90	289	4	72	46
Michigan	Houghton	1.14	0.880	-10	85	164	2	82	33
Michigan	Lansing	1.15	0.722	0	90	315	4	79	46
Michigan	Muskegon	1.17	0.741	10	85	228	2	114	45
Michigan	Sault Ste. Marie	1.14	0.957	0	85	99	2	50	38
Michigan	Traverse City	1.16	0.773	0	90	242	4	61	44
Minnesota	Int'nl Falls	1.14	0.944	-20	85	150	2	75	36
Minnesota	Minneapolis	1.14	0.717	-10	90	357	4	89	43
Minnesota	Rochester	1.16	0.768	-10	90	259	4	65	42
Minnesota	Saint Cloud	1.16	0.813	-10	90	247	4	62	43
Mississippi	Jackson	1.20	0.184	30	95	1130	12	94	65
Mississippi	Meridian	1.19	0.207	30	95	1021	12	85	61
Missouri	Columbia	1.23	0.456	10	100	686	13	53	52
Missouri	Kansas City	1.19	0.417	10	95	809	12	67	52
Missouri	Springfield	1.22	0.412	0	95	687	12	57	54
Missouri	St. Louis	1.20	0.412	10	95	757	12	63	54
Montana	Billings	1.41	0.697	0	95	391	6	65	45
Montana	Cut Bank	1.39	0.963	-10	85	199	2	100	39
Montana	Dillon	1.53	0.780	-10	90	415	4	104	42
Montana	Glasgow	1.34	0.788	-20	95	276	6	46	41
Montana	Great Falls	1.41	0.811	-10	90	309	4	77	44
Montana	Helena	1.47	0.827	-10	95	253	6	42	42
Montana	Kalispell	1.41	0.941	0	90	279	4	70	40
Montana	Lewistown	1.42	0.889	-10	95	235	6	39	41
Montana	Miles City	1.40	0.723	-10	95	403	6	67	43
Montana	Missoula	1.44	0.852	-10	95	263	6	44	42
Nebraska	Grand Island	1.24	0.582	0	95	561	6	94	48
Nebraska	Norfolk	1.27	0.580	0	95	577	6	96	47
Nebraska	North Platte	1.32	0.638	-10	100	502	8	63	46

Nebraska	Omaha	1.20	0.536	0	95	527	6	88	49
Nebraska	Scottsbluff	1.39	0.644	0	100	485	8	61	45
Nevada	Elko	1.54	0.834	0	95	349	6	58	44
Nevada	Ely	1.52	0.918	0	90	374	4	94	42
Nevada	Las Vegas	1.51	0.131	30	110	1439	12	120	64
Nevada	Lovelock	1.70	0.480	10	100	3483	8	435	51
Nevada	Reno	1.52	0.751	10	95	407	6	68	48
Nevada	Tonopah	1.52	0.608	20	95	632	6	105	48
Nevada	Winnemucca	1.55	0.682	10	100	634	8	79	48
Nevada	Yucca Flats Test Site	1.68	0.355	20	100	884	4	221	55
New Hampshire	Concord	1.19	0.793	0	90	345	4	86	44
New Jersey	Atlantic City	1.21	0.538	10	95	463	12	39	51
New Jersey	Lakehurst	1.20	0.487	10	95	589	6	98	52
New Jersey	Newark	1.21	0.492	10	95	471	6	79	52
New Mexico	Albuquerque	1.44	0.420	20	95	790	7	113	54
New Mexico	Clayton	1.47	0.475	10	95	745	7	106	53
New Mexico	Roswell	1.49	0.266	20	100	1415	8	177	59
New Mexico	Truth or Consequences	1.56	0.293	30	100	1207	7	172	59
New Mexico	Tucumcari	1.42	0.354	20	100	902	10	90	56
New York	Albany	1.19	0.724	0	90	319	4	80	47
New York	Binghamton	1.14	0.826	0	85	175	2	88	44
New York	Buffalo	1.18	0.725	0	90	283	4	71	46
New York	Massena	1.18	0.829	-10	90	245	4	61	42
New York	New York City	1.21	0.505	10	95	432	6	72	52
New York	New York-La Guardia	1.21	0.465	20	90	493	4	123	54
New York	Rochester	1.20	0.686	0	90	331	4	83	45
New York	Syracuse	1.16	0.745	0	90	324	4	81	46
North Carolina	Asheville	1.21	0.548	20	90	426	10	43	53
North Carolina	Cape Hatteras	1.10	0.264	30	90	721	12	60	59
North Carolina	Charlotte	1.19	0.312	20	95	802	12	67	58
North Carolina	Cherry Point	1.19	0.214	30	95	954	12	80	62
North Carolina	Greensboro	1.17	0.402	10	95	667	13	51	56
North Carolina	Raleigh	1.18	0.352	20	95	667	12	56	57
North Carolina	Wilmington	1.15	0.222	30	95	796	13	61	61

North Dakota	Bismarck	1.22	0.810	-20	90	354	4	89	39
North Dakota	Fargo	1.18	0.769	-20	90	397	4	99	39
North Dakota	Minot	1.23	0.855	-10	90	293	4	73	39
Ohio	Akron	1.16	0.670	0	90	319	4	80	48
Ohio	Cleveland	1.19	0.665	10	90	395	4	99	48
Ohio	Columbus	1.16	0.589	10	90	570	4	143	50
Ohio	Dayton	1.18	0.625	0	90	527	10	53	50
Ohio	Mansfield	1.17	0.646	0	90	529	4	132	49
Ohio	Toledo	1.19	0.690	0	90	402	4	101	48
Ohio	Youngstown	1.15	0.722	0	85	281	2	141	47
Oklahoma	Oklahoma City	1.27	0.296	10	100	859	13	66	57
Oklahoma	Tulsa	1.26	0.291	10	100	1009	13	78	58
Oregon	Astoria	1.17	0.987	30	85	25	2	13	49
Oregon	Boise	1.48	0.635	10	100	526	8	66	49
Oregon	Burns	1.44	0.833	10	90	296	4	74	45
Oregon	Eugene	1.32	0.803	30	90	262	4	66	50
Oregon	Medford	1.45	0.591	20	100	456	8	57	51
Oregon	North Bend	1.15	0.999	40	85	12	2	6	50
Oregon	Pendleton	1.50	0.608	20	100	420	8	53	49
Oregon	Portland	1.33	0.763	30	90	174	4	44	51
Oregon	Redmond	1.45	0.874	0	90	311	4	78	45
Oregon	Salem	1.34	0.833	30	95	253	6	42	50
Palau	Koror Island	1.10	0	60	90	3690	12	307	81
Pennsylvania	Allentown	1.18	0.620	10	90	381	4	95	49
Pennsylvania	Bradford	1.13	0.920	0	85	160	2	80	46
Pennsylvania	Erie	1.13	0.749	0	85	298	2	149	47
Pennsylvania	Harrisburg	1.21	0.527	20	95	503	6	84	47
Pennsylvania	Philadelphia	1.18	0.497	20	95	514	12	43	52
Pennsylvania	Pittsburgh	1.17	0.637	10	90	371	4	93	48
Pennsylvania	Wilkes-Barre	1.16	0.710	0	90	336	4	84	47
Pennsylvania	Williamsport	1.19	0.645	10	90	396	4	99	45
Puerto Rico	San Juan	1.13	0	60	90	3151	12	263	74
Rhode Island	Providence	1.19	0.664	10	90	237	4	59	48
South Carolina	Charleston	1.19	0.181	30	95	950	12	79	62

South Carolina	Columbia	1.23	0.226	20	100	931	13	72	61
South Carolina	Greenville	1.19	0.316	20	95	800	12	67	57
South Dakota	Huron	1.21	0.757	-10	95	460	6	77	42
South Dakota	Pierre	1.36	0.646	-10	105	459	10	46	44
South Dakota	Rapid City	1.35	0.739	-10	95	408	6	68	45
South Dakota	Sioux Falls	1.29	0.665	-10	100	436	8	55	44
Tennessee	Bristol	1.22	0.484	20	90	598	10	60	51
Tennessee	Chattanooga	1.23	0.309	20	100	913	13	70	57
Tennessee	Knoxville	1.17	0.350	10	90	767	11	70	56
Tennessee	Memphis	1.18	0.238	20	95	974	13	75	60
Tennessee	Nashville	1.23	0.326	10	100	832	13	64	57
Texas	Abilene	1.35	0.186	20	100	1165	11	106	62
Texas	Amarillo	1.36	0.419	10	95	820	9	91	54
Texas	Austin	1.25	0.099	30	100	1375	13	106	65
Texas	Brownsville	1.18	0.036	40	95	1991	13	153	71
Texas	Corpus Christi	1.19	0.052	40	100	2150	14	154	70
Texas	Del Rio-Laughlin	1.35	0.088	40	100	2305	11	210	69
Texas	El Paso	1.40	0.203	30	100	1204	10	120	62
Texas	Fort Worth	1.26	0.161	30	100	1374	13	106	63
Texas	Houston	1.18	0.100	30	95	1308	13	101	66
Texas	Kingsville	1.23	0.051	40	100	2535	13	195	72
Texas	Laredo	1.31	0.046	40	105	2051	14	147	73
Texas	Lubbock	1.34	0.306	10	95	926	9	103	58
Texas	Lufkin	1.23	0.133	30	100	1380	13	106	65
Texas	Midland	1.39	0.215	20	100	1240	10	124	62
Texas	Port Arthur	1.16	0.103	40	95	1217	13	94	66
Texas	San Angelo	1.35	0.197	20	100	1493	11	136	64
Texas	San Antonio	1.25	0.105	30	100	1351	13	104	66
Texas	Sherman-Perrin	1.28	0.180	30	100	1493	12	124	64
Texas	Victoria	1.20	0.071	40	95	1761	12	147	68
Texas	Waco	1.28	0.141	30	100	1399	12	117	64
Texas	Wichita Falls	1.32	0.205	20	105	1264	14	90	60
Utah	Bryce Canyon	1.40	0.853	0	85	386	4	96	40
Utah	Cedar City	1.48	0.651	0	95	770	6	128	48

Utah	Salt Lake City	1.51	0.518	20	100	705	8	88	39
Vermont	Burlington	1.16	0.796	0	90	216	4	54	43
Virginia	Lynchburg	1.20	0.455	10	90	611	10	61	54
Virginia	Norfolk	1.18	0.327	20	95	614	12	51	57
Virginia	Richmond	1.18	0.388	20	95	693	12	58	54
Virginia	Roanoke	1.23	0.450	20	95	617	11	56	54
Washington	Olympia	1.31	0.887	30	90	115	4	29	48
Washington	Quillayute	1.19	0.994	30	85	31	2	15	48
Washington	Seattle	1.26	0.885	30	85	105	2	53	48
Washington	Spokane	1.51	0.774	0	95	311	6	52	46
Washington	Whidbey Island	1.22	0.936	30	85	61	2	30	50
Washington	Yakima	1.38	0.745	10	95	380	6	63	48
Washington DC	Washington	1.19	0.502	10	95	560	12	47	52
West Virginia	Charleston	1.17	0.507	10	90	589	11	54	53
West Virginia	Elkins	1.14	0.785	0	85	265	9	29	52
West Virginia	Huntington	1.17	0.475	10	90	593	11	54	53
Wisconsin	Duluth	1.17	0.936	-20	85	119	2	60	35
Wisconsin	Eau Claire	1.16	0.769	-20	90	303	4	76	42
Wisconsin	Green Bay	1.16	0.801	-10	90	235	4	59	42
Wisconsin	La Crosse	1.17	0.714	-10	90	348	4	87	45
Wisconsin	Madison	1.17	0.743	-10	90	360	4	90	44
Wisconsin	Milwaukee	1.15	0.761	0	90	236	4	59	45
Wyoming	Casper	1.47	0.825	-10	95	427	6	71	43
Wyoming	Cheyenne	1.43	0.851	0	90	285	4	71	44
Wyoming	Lander	1.45	0.808	0	90	232	4	58	41
Wyoming	Rock Springs	1.48	0.901	0	90	222	4	56	40
Wyoming	Sheridan	1.41	0.802	-10	95	406	6	68	44

Appendix D. Normalized Hourly Factor by End-Use by Daytype and Month

See pdf file EnduseHourlyFactors.pdf
http://hes.lbl.gov/hes/documentation/EnduseHourlyFactors.pdf

Appendix E. HVAC modeling

THE USE OF DOE-2 IN THE *HOME ENERGY SAVER*

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EXECUTIVE SUMMARY

The space-conditioning calculation section of the *Home Energy Saver* utilizes the building energy simulation program DOE-2.1E. DOE-2 macros are employed extensively to calculate input quantities, convert input quantities to the correct formats, and select the correct lines of conditional DOE-2 code for each house simulation. Many components of the house description can be varied, including:

- Weather data;
- Materials and constructions;
- Doors;
- Windows and skylights;
- Foundations;
- Attics and roofs;
- House geometry;
- House shading and buffering;
- Internal loads;
- Infiltration and natural ventilation;
- HVAC systems; and
- Ducts and pipes.

Inputs and outputs are passed to and from the DOE-2 code by the surrounding Web programming.

In the future, EnergyPlus could be substituted for DOE-2 in the *Home Energy Saver*.

1. INTRODUCTION

The *Home Energy Saver* (LBNL 2003) is a World Wide Web site devoted to residential energy analysis. The space-conditioning calculation section of the *Home Energy Saver* utilizes the detailed hourly building energy simulation program DOE-2.1E (Birdsall et al. 1990). User inputs for the energy-related characteristics of houses are collected and interpreted by Web programming outside of DOE-2 (Pinckard et al. 2003). The prepared data are then passed to a master DOE-2 Building Description Language (BDL) file (Winkelmann et al. 1993a) through macro input variables (Winkelmann et al. 1993b). These and other macro variables internal to the DOE-2 BDL file are used to calculate input quantities, convert input quantities to the correct formats, and select the correct lines of conditional DOE-2 code for each house simulation. DOE-2 output files are scanned by a second set of Web programming. The relevant output quantities are captured, converted and compiled, and returned for display on the Web (Pinckard et al. 2003).

The following report sections describe inputs to the DOE-2 model, the details of the model, and outputs from the DOE-2 model.

2. INPUTS TO THE DOE-2 MODEL

The DOE-2 macro input variables used in the *Home Energy Saver* are listed in Table 1, along with their definitions and possible values. Conditional variables are those used only when other variables have certain values.

3. THE DOE-2 MODEL

1.1. Weather Data

The 239 second-generation Typical Meteorological Year (TMY2) weather data files (Marion and Urban 1995), 42 first-generation Typical Meteorological Year (TMY) weather data files (NCDC 1981), and four California Climate Zone (CTZ) weather data files listed in Table 2 are accessible in the *Home Energy Saver*. Corresponding location and climatic data (U.S. DOE 1998) are also shown for comparison. Of these parameters, only the elevation is not automatically read from weather data files by DOE-2; its value must be input explicitly, as listed in Table 1.

1.2. Materials and Constructions

Table 3 shows the physical properties of the construction materials that can be modeled in the *Home Energy Saver*. The constructions comprised of these materials are listed in Table 4. Of special note are interior partition walls, floors, and ceilings, which are modeled as half-constructions and doubled in area to account correctly for radiative heat transfer between interior surfaces.

Foundation constructions are handled directly in the DOE-2 BDL file. Two-dimensional response factors for all other constructions are precalculated using a program called WALFERF. These response factors are accessed and used by DOE-2 during simulation.

Surface roughnesses are used in the calculation of exterior air film coefficients in DOE-2. Table 5 shows the roughness codes (Winkelmann et al. 1993a) assumed for the exterior surfaces of the constructions listed in Table 4.

Home Energy Saver users can specify the relative shades of exterior wall and roof surfaces. The solar absorptance values assigned to these shades are shown in Table 6.

1.3. Doors

The nominal door types shown in Table 7 can be modeled in the *Home Energy Saver*. The U-factors for these door types are drawn from ASHRAE (2001a). Alternatively, users can specify customized door types by U-factor. These U-factors incorporate the exterior air film coefficient at ASHRAE winter design conditions, while DOE-2 calculates variable exterior air film coefficients according to the hourly weather data supplied. Therefore, the input door U-factors are adjusted in DOE-2 macros according to the equation

$$U' = 1 / [(1 / U) - (1 / h_o)] \tag{1}$$

where

U = design coefficient of heat transfer for a door (Btu/h·ft²·˚F)
h_o = design exterior air film coefficient (Btu/h·ft²·˚F)
U' = coefficient of heat transfer for a door, excluding the effect of the exterior air film coefficient (Btu/h·ft²·˚F)

In accordance with the most up-to-date calculation, the design exterior air film coefficient is assigned a value of 5.112 Btu/h·ft²·˚F (Köhler 2002).

All doors specified in the *Home Energy Saver* are assumed to be 6.67 ft high and 3 ft wide.

1.4. Windows and Skylights

The nominal window and skylight types shown in Table 8 can be modeled in the *Home Energy Saver*. As with the doors, their properties are drawn from ASHRAE (2001a). Users can also specify customized window and skylight types by U-factor and solar heat gain coefficient (SHGC). The U-factors are adjusted in DOE-2 macros in the same way as those of doors. Because DOE-2 uses the shading coefficient (SC) as the measure of solar transmission through fenestration, the SHGCs must be adjusted in DOE-2 macros according to the equation

$$SC = SHGC / 0.87 \tag{2}$$

where

SHGC = whole-window or whole-skylight solar heat gain coefficient (dimensionless)
SC = whole-window or whole-skylight shading coefficient (dimensionless)

1.5. Foundations

Slabs-on-grade, unconditioned and conditioned basements, and unvented and vented crawlspaces, with and without insulation, can be modeled in the *Home Energy Saver*, as shown in Table 10. Mixed or “averaged” foundation types cannot be simulated. Basements are assumed to be 8 ft high, with 1 ft above grade for standard basements and 4 ft above grade for raised basements in split-level houses. Crawlspaces are assumed to be 2.5 ft high and entirely above grade.

Foundation heat transfer is simulated according to the method first devised by Huang et al. (1988) and subsequently updated (Winkelmann 1998; Huang 2003). This method utilizes effective foundation U-factors and fictitious foundation insulation layers to account for the insulating value of the surrounding soil. The effective U-factors for the foundation types modeled in the *Home Energy Saver* are included in Table 10.

1.6. Attics and Roofs

Unconditioned attics, conditioned attics, and cathedral or vaulted ceilings can be modeled in the *Home Energy Saver*. Mixed or “averaged” attic/roof types cannot be simulated.

Roof apexes are always modeled parallel to the long axes of houses. Only one skylight type can be modeled per roof.

1.7. House Geometry

Figure 1 indicates the necessary input dimensions for the eight types of house floor plans that can be modeled in the *Home Energy Saver*. Figure 2 provides further insight into the variety of house floor plans that can be treated.

Different wall, door, and window types can be modeled on different sides of houses. However, there is no provision for modeling mixed types on the same side.

Door and window areas are divided proportionately among the wall elements on a given façade. Window areas are also divided proportionately among the stories of a given façade. To avoid incorrect shading of doors and windows by one another, doors are always anchored at the left edges of walls, while windows are centered in walls. Window areas extend the full height of stories, resulting in offsetting errors in shading by other surfaces and objects.

Interior wall areas are taken to be half as great as conditioned floor areas, exclusive of basements and attics.

1.8. House Shading and Buffering

House shading by roof eaves, patios, carports, trellises, and similar overhangs can be modeled in the *Home Energy Saver*. Different extensions can be specified on different sides of houses. All overhangs are positioned at the roof line and assumed to run the lengths of the façades from which they extend. They are assigned a uniform solar transmittance of 0.

DOE-2 test simulations were performed to ascertain the buffering effects of a garage on different sides of a small, single-story house in different climates. Reductions in heating and cooling energy consumption of 1.5% were consistently obtained. These effects should be even less for larger houses. Because estimates of energy consumption from the *Home Energy Saver* are intended to be conservative, garages are not considered in the model.

Shade trees and neighboring houses can be specified independently on different sides of houses in the *Home Energy Saver*. Both are centered with respect to house façades. Trees are considered to have 6-ft-tall trunks, assigned widths of 15 ft, and positioned 10 ft away from the houses they shade. Neighboring houses are assigned the same widths as the houses they shade and positioned 20 ft away. Trees are assigned a solar transmittance of 0.70.

1.9. Internal Loads

House occupants are assumed to release sensible and latent loads of 230 Btu/h and 190 Btu/h, respectively, in the *Home Energy Saver*. Internal gains from appliances and lights are passed to DOE-2 from elsewhere in the *Homer Energy Saver* (Pinckard et al. 2003). Gains from appliances are assumed to be 80% sensible and 20% latent. The typical load profiles plotted in Figure 3 apply to all 365 days of the simulated year.

1.10. Infiltration and Natural Ventilation

The Sherman-Grimsrud Method (Sherman 1980; Winkelmann et al. 1993b) is the specified infiltration calculation option in the *Home Energy Saver*. Terrain parameters for suburban environments are used. Fractional leakage areas (FLAs) for conditioned spaces above grade are selected outside of DOE-2 according to user-specified house airtightness, vintage, and number of stories (Pinckard et al. 2003) and passed to DOE-2 through a macro input variable. Alternatively, users can specify measured or estimated air leakage rates. These leakage rates are converted to SI units in a DOE-2 macro according to the simple relationship

$$Q_{50} = 0.0004719474\ Q_{50ip} \qquad (3)$$

where

Q_{50ip} = conditioned house envelope air leakage rate at 50 Pa (ft^3/min)
Q_{50} = conditioned house envelope air leakage rate at 50 Pa (m^3/s)

Conditioned house envelope air leakage rates are then found using the equation

$$Q_4 = Q_{50} (4 / 50)^{0.65} \tag{4}$$

where

Q_{50} = conditioned house envelope air leakage rate at 50 Pa (m^3/s)
Q_4 = conditioned house envelope air leakage rate at 4 Pa (m^3/s)

Effective leakage areas (ELAs) of conditioned house envelopes are determined using the equation

$$ELA = Q_4 / [4 (2 / \rho)]^{0.5} \tag{5}$$

where

Q_4 = conditioned house envelope air leakage rate at 4 Pa (m^3/s)
ρ = air density (1.2 kg/m^3)
ELA = effective leakage area of a conditioned house envelope (dimensionless)

Lastly, ELAs are converted to FLAs, including a unit conversion, using the relationship

$$FLA = (ELA / 0.09290304) / A_f \tag{6}$$

where

ELA = effective leakage area of a conditioned house envelope (dimensionless)
A_f = conditioned house floor area (ft^2)
FLA = fractional leakage area of a conditioned house envelope (dimensionless)

For simplicity, basements are assumed to have no air exchange with the exterior. Unvented and vented crawlspaces are assigned FLAs of 0.0015 and 0.0030, respectively. Unconditioned attics are assigned FLAs of 0.00242 (Treidler 1993).

The opening of windows for natural ventilation is simulated whenever the exterior temperature and humidity would result in a cooling effect. One quarter of the total user-specified window area is assumed open, and a discharge coefficient of 0.6 is applied.

1.11. HVAC Systems

The HVAC system types shown in Table 11 can be modeled in the *Home Energy Saver*. Performance curves for equipment efficiency as a function of part-load ratio are drawn from

Henderson et al. (1999). Curves for equipment capacity and efficiency as functions of outdoor temperature are unpublished LBNL derivations based on commercially available equipment performance data.

Hot water heating is simulated in DOE-2 for tankless and indirect boiler types. The results for system types simulated as other system types are converted after capture in the Web programming as necessary.

Window-mounted air conditioners that are controlled manually (i.e., by on-off switches rather than thermostats), whole-house fans, portable fans, and portable electric resistance heaters are treated separately from DOE-2 as appliances (Pinckard et al. 2003).

1.12. Ducts and Pipes

A simplified estimate of duct delivery efficiency, based on draft ASHRAE Standard 152P (ASHRAE 2001b), is currently used in the *Home Energy Saver*. This single numerical value is a weighted average corresponding to the pre-estimated annual heating and cooling loads for the house to be modeled. The development of a DOE-2 function for the hourly calculation of duct efficiency, based on the same Standard, is proposed.

Boiler pipes are simply treated. Uninsulated and insulated pipes are assigned delivery efficiencies of 0.90 and 0.95, respectively.

4. OUTPUTS FROM THE DOE-2 MODEL

Table 12 provides a brief description of the outputs captured from DOE-2 simulations in the *Home Energy Saver*. Hot water heating results are captured for tankless and indirect boilers.

5. FUTURE WORK

In the future, EnergyPlus could be substituted for DOE-2.1E as the space-conditioning energy calculator in the *Home Energy Saver*. This conversion would allow the simulation of such innovative HVAC systems as ground-source heat pumps, evaporative coolers, and hydronic radiant heating and cooling systems.

6. ACKNOWLEDGMENT

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7. REFERENCES

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). 2001a. *ASHRAE Handbook: 2001 Fundamentals*. Atlanta, Georgia: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). 2001b. *Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems*. ASHRAE Standard 152P. In preparation. Atlanta, Georgia: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Birdsall, B., W.F. Buhl, K.L. Ellington, A.E. Erdem, and F.C. Winkelmann. 1990. *Overview of the DOE-2 Building Energy Analysis Program, Version 2.1D*. LBNL-19735, Rev. 1. Berkeley, California: Lawrence Berkeley National Laboratory.

Henderson, H., Y.J. Huang, and D. Parker. 1999. *Residential Equipment Part Load Curves for Use in DOE-2*. LBNL-42175. Berkeley, California: Lawrence Berkeley National Laboratory.

Huang, Y.J. 2003. In preparation. *Building Energy Simulation User News.*

Huang, Y.J., L.S. Shen, J.C. Bull, L.F. Goldberg. 1988. "Whole-House Simulation of Foundation Heat Flows Using the DOE-2.1C Program." *ASHRAE Transactions* 94(2): 936–944.

Köhler, C. 2002. Personal communication. October 10.

Lawrence Berkeley National Laboratory (LBNL). 2003. *Home Energy Saver*. World Wide Web site: http://HomeEnergySaver.lbl.gov.

Marion, W., and K. Urban. 1995. *User's Manual for TMY2s*. TP-463-7668. Golden, Colorado: National Renewable Energy Laboratory.

National Climatic Data Center (NCDC). 1981. *Typical Meteorological Year User's Manual*. TD-9734. Ashville, North Carolina: National Climatic Data Center.

Pinckard, M.J., R.E. Brown, J.D. Lutz, M.M. Moezzi, and E. Mills. 2003. *Documentation of Calculational Methodology and Input Data for LBNL's* Home Energy Saver *Web Site*. LBNL-51938. In preparation. Berkeley, California: Lawrence Berkeley National Laboratory.

Sherman, M.H. 1980. *Air Infiltration in Buildings*. LBNL-10712. Berkeley, California: Lawrence Berkeley National Laboratory.

Treidler, B. 1993. Personal communication.

U.S. Department of Energy (U.S. DOE). 1995. *House of Straw*. DOE/G010094-01. Washington, D.C.: U.S. Department of Energy.

U.S. Department of Energy (U.S. DOE). 1998. *EnergyPlus*. World Wide Web site: http://www.eren.doe.gov/buildings/energy_tools/energyplus/. Accessed December 2002.

Winkelmann, F.C. 1998. "Underground Surfaces: How to Get a Better Underground Surface Heat Transfer Calculation in DOE-2.1E." *Building Energy Simulation User News* 19(1): 6–13.

Winkelmann, F.C., B.E. Birdsall, W.F. Buhl, K.L. Ellington, A.E. Erdem, J.J. Hirsch, and S. Gates. 1993a. *DOE-2 BDL Summary, Version 2.1E*. LBNL-34946. Berkeley, California: Lawrence Berkeley National Laboratory.

Winkelmann, F.C., B.E. Birdsall, W.F. Buhl, K.L. Ellington, A.E. Erdem, J.J. Hirsch, and S. Gates. 1993b. *DOE-2 Supplement, Version 2.1E*. LBNL-34947. Berkeley, California: Lawrence Berkeley National Laboratory.

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver*

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
session_id		Individual user session identification number	(N/A)	(N/A)	Assigned in the *Home Energy Saver*
altitude		Elevation of the corresponding weather location	(Refer to Table 2)	ft	Assigned in the *Home Energy Saver*
floor_cons		Floor (over foundation) construction type	(Refer to Table 4)	(N/A)	User-defined
wall_cons_f		Exterior wall construction type on the front side of the house	(Refer to Table 4)	(N/A)	User-defined
wall_cons_l		Exterior wall construction type on the left side of the house	(Refer to Table 4)	(N/A)	User-defined
wall_cons_b		Exterior wall construction type on the back side of the house	(Refer to Table 4)	(N/A)	User-defined
wall_cons_r		Exterior wall construction type on the right side of the house	(Refer to Table 4)	(N/A)	User-defined
ceil_cons		Ceiling construction type	(Refer to Table 4)	(N/A)	User-defined
roof_cons		Roof construction type	(Refer to Table 4)	(N/A)	User-defined
wall_rough_f		Exterior wall roughness on the front side of the house	(Refer to Table 5)	(N/A)	Derived from wall_cons_f
wall_rough_l		Exterior wall roughness on the left side of the house	(Refer to Table 5)	(N/A)	Derived from wall_cons_l
wall_rough_b		Exterior wall roughness on the back side of the house	(Refer to Table 5)	(N/A)	Derived from wall_cons_b
wall_rough_r		Exterior wall roughness on the right side of the house	(Refer to Table 5)	(N/A)	Derived from wall_cons_r
roof_rough		Exterior roof roughness	(Refer to Table 5)	(N/A)	Derived from roof_cons
wall_abs_f		Exterior wall absorptance on the front side of the house	(Refer to Table 6)	-	User-defined
wall_abs_l		Exterior wall absorptance on the left side of the house	(Refer to Table 6)	-	User-defined
wall_abs_b		Exterior wall absorptance on the back side of the house	(Refer to Table 6)	-	User-defined
wall_abs_r		Exterior wall absorptance on the right side of the house	(Refer to Table 6)	-	User-defined

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
roof_abs		Exterior roof absorptance	(Refer to Table 6)	-	User-defined
door_f		Number of doors on the front side of the house	0:4	(N/A)	User-defined
door_l		Number of doors on the left side of the house	0:4	(N/A)	User-defined
door_b		Number of doors on the back side of the house	0:4	(N/A)	User-defined
door_r		Number of doors on the right side of the house	0:4	(N/A)	User-defined
door_type_f		Door type on the front side of the house	(Refer to Table 7), user	(N/A)	User-defined
door_type_l		Door type on the left side of the house	(Refer to Table 7), user	(N/A)	User-defined
door_type_b		Door type on the back side of the house	(Refer to Table 7), user	(N/A)	User-defined
door_type_r		Door type on the right side of the house	(Refer to Table 7), user	(N/A)	User-defined
	door_u_f	Door U-factor on the front side of the house	0.00:5.00	$Btu/h \cdot ft^2 \cdot °F$	User-defined if door_type_f = user
	door_u_l	Door U-factor on the left side of the house	0.00:5.00	$Btu/h \cdot ft^2 \cdot °F$	User-defined if door_type_l = user
	door_u_b	Door U-factor on the back side of the house	0.00:5.00	$Btu/h \cdot ft^2 \cdot °F$	User-defined if door_type_b = user
	door_u_r	Door U-factor on the right side of the house	0.00:5.00	$Btu/h \cdot ft^2 \cdot °F$	User-defined if door_type_r = user
window_area_f		Window area on the front side of the house	0.00:300.00	ft^2	User-defined
window_area_l		Window area on the left side of the house	0.00:300.00	ft^2	User-defined
window_area_b		Window area on the back side of the house	0.00:300.00	ft^2	User-defined
window_area_r		Window area on the right side of the house	0.00:300.00	ft^2	User-defined

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued*)*

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
skylt_area		Skylight area	0.00:300.00	ft^2	User-defined
window_type_f		Window type on the front side of the house	(Refer to Table 8), user	(N/A)	User-defined
window_type_l		Window type on the left side of the house	(Refer to Table 8), user	(N/A)	User-defined
window_type_b		Window type on the back side of the house	(Refer to Table 8), user	(N/A)	User-defined
window_type_r		Window type on the right side of the house	(Refer to Table 8), user	(N/A)	User-defined
skylt_type		Skylight type	(Refer to Table 8), user	(N/A)	User-defined
	window_u_f	Window U-factor on the front side of the house	0.00:5.00	$Btu/h{\cdot}ft^2{\cdot}°F$	User-defined if window_type_f = user
	window_u_l	Window U-factor on the left side of the house	0.00:5.00	$Btu/h{\cdot}ft^2{\cdot}°F$	User-defined if window_type_l = user
	window_u_b	Window U-factor on the back side of the house	0.00:5.00	$Btu/h{\cdot}ft^2{\cdot}°F$	User-defined if window_type_b = user
	window_u_r	Window U-factor on the right side of the house	0.00:5.00	$Btu/h{\cdot}ft^2{\cdot}°F$	User-defined if window_type_r = user
	skylt_u	Skylight U-factor	0.00:5.00	$Btu/h{\cdot}ft^2{\cdot}°F$	User-defined if skylt_type = user
	window_shgc_f	Window solar heat gain coefficient on the front side of the house	0.00:1.00	-	User-defined if window_type_f = user
	window_shgc_l	Window solar heat gain coefficient on the left side of the house	0.00:1.00	-	User-defined if window_type_l = user
	window_shgc_b	Window solar heat gain coefficient on the back side of the house	0.00:1.00	-	User-defined if window_type_b = user
	window_shgc_r	Window solar heat gain coefficient on the right side of the house	0.00:1.00	-	User-defined if window_type_r = user
	skylt_shgc	Skylight solar heat gain coefficient	0.00:1.00	-	User-defined if skylt_type = user
window_ins_f		Movable window insulation level on the front side of the house	0.0:12.0	$h{\cdot}ft^2{\cdot}°F/Btu$	User-defined
window_ins_l		Movable window insulation level on the left side of the house	0.0:12.0	$h{\cdot}ft^2{\cdot}°F/Btu$	User-defined

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
window_ins_b		Movable window insulation level on the back side of the house	0.0:12.0	h·ft^2·°F/Btu	User-defined
window_ins_r		Movable window insulation level on the right side of the house	0.0:12.0	h·ft^2·°F/Btu	User-defined
skylt_ins		Movable skylight insulation level	0.0:12.0	h·ft^2·°F/Btu	User-defined
window_shd_f		Movable window shade type on the front side of the house	(Refer to Table 9)	(N/A)	User-defined
window_shd_l		Movable window shade type on the left side of the house	(Refer to Table 9)	(N/A)	User-defined
window_shd_b		Movable window shade type on the back side of the house	(Refer to Table 9)	(N/A)	User-defined
window_shd_r		Movable window shade type on the right side of the house	(Refer to Table 9)	(N/A)	User-defined
skylt_shd		Movable skylight shade type	(Refer to Table 9)	(N/A)	User-defined
orientation		Compass direction the front of the house faces		°	User-defined
		North	0		
		Northeast	45		
		East	90		
		Southeast	135		
		South	180		
		Southwest	225		
		West	270		
		Northwest	315		
house_geom		House geometry or shape	(Refer also to Figures 1 and 2)	(N/A)	User-defined
		Rectangular	rectangle		
		L-shaped	L_shape		
		Forward-S-shaped	for_S		
		Backward-S-shaped	back_S		
		T-shaped	T_shape		
		U-shaped	U_shape		
		Split-level or tri-level	split		
		Townhouse	town		

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
	front	Front side of the house	side1, side2, side3, side4	(N/A)	User-defined if house_geom ≠ rectangle, town
d1		House dimension	1.00:200.00	ft	User-defined
d2		House dimension	1.00:200.00	ft	User-defined
	d1a	House dimension	1.00:200.00	ft	User-defined if house_geom ≠ rectangle, town
	d2a	House dimension	1.00:200.00	ft	User-defined if house_geom ≠ rectangle, split, town
	d1c	House dimension	1.00:200.00	ft	User-defined if house_geom ≠ rectangle, L_shape, split, town
	d2c	House dimension	1.00:200.00	ft	User-defined if house_geom ≠ rectangle, L_shape, split, town
	town_pos	Townhouse position in the building	left, middle, right	(N/A)	User-defined if house_geom = town
stories		Number of stories in the house	1:4	(N/A)	User-defined
ceil_height		Average floor-to-ceiling height in the house	6.00:20.00	ft	User-defined
found_type		Foundation type	(Refer to Table 10)	(N/A)	User-defined
found_ins		Foundation insulation level	(Refer to Table 10)	(N/A)	User-defined
attic_type		Attic/roof type		(N/A)	User-defined
		Unconditioned attic	uncond_attic		
		Conditioned attic	cond_attic		
		Cathedral ceiling	cath_ceil		
roof_pitch		Units of roof rise per 12 units of roof run		-	User-defined
		0:12 (flat)	0		
		1:12	1		
		2:12	2		
		3:12	3		
		4:12	4		
		5:12	5		
		6:12 (steep)	6		
		7:12	7		

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
		8:12 (very steep)	8		
		9:12	9		
		10:12	10		
roof_ovhg_f		Overhang extension on the front side of the house	0.50:50.00	ft	User-defined
roof_ovhg_l		Overhang extension on the left side of the house	0.50:50.00	ft	User-defined
roof_ovhg_b		Overhang extension on the back side of the house	0.50:50.00	ft	User-defined
roof_ovhg_r		Overhang extension on the right side of the house	0.50:50.00	ft	User-defined
tree_f		Shade tree height in front of the house	0, 6:200	ft	User-defined
tree_l		Shade tree height to the left of the house	0, 6:200	ft	User-defined
tree_b		Shade tree height in back of the house	0, 6:200	ft	User-defined
tree_r		Shade tree height to the right of the house	0, 6:200	ft	User-defined
neighbor_f		Number of stories in the neighboring house in front	0:4	(N/A)	User-defined
neighbor_l		Number of stories in the neighboring house to the left	0:4	(N/A)	User-defined
neighbor_b		Number of stories in the neighboring house in back	0:4	(N/A)	User-defined
neighbor_r		Number of stories in the neighboring house to the right	0:4	(N/A)	User-defined
occupants		Number of occupants in the house	1:20	(N/A)	User-defined
lights_kWh		Internal gains from lighting	0.0:5,000.0	kWh	Sent from Lighting module
equip_kWh		Internal gains from equipment (appliances)	0.0:25,000.0	kWh	Sent from Appliances and Miscellaneous Equipment modules
airtight		Application of airsealing to the house	no, yes, user	(N/A)	User-defined

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
	frac_leak_area	Fractional leakage area of the house	0.000000:1.000000	-	Derived from airtight if airtight = no, yes
	Q50ip	Measured or estimated air leakage rate through the house	0.00:25,000.00	ft^3/min	User-defined if airtight = user
heat_type		Heating system type	(Refer to Table 11)	(N/A)	User-defined
	comb_bl	Boiler/water heater combination type	separate, tankless, indirect	(N/A)	User-defined if heat_type = gbl, obl
	dhw_draw	Daily domestic hot water draw	0:1,000	gal	Sent from Appliances module if heat_type = gbl, obl and comb_bl = tankless, indirect
	dhw_loss	Instantaneous domestic hot water tank loss	0.00:1.00	-	Sent from Appliances module if heat_type = gbl, obl and comb_bl = tankless, indirect
cool_type		Cooling system type	(Refer to Table 11)	(N/A)	User-defined
heat_cap		Heating system capacity	0, 1,000:400,000	Btu/h	User-defined
cool_cap		Cooling system capacity	0, 1,000:400,000	Btu/h	User-defined
heat_eff		Heating system efficiency	0:100 (AFUE), 1.00:20.00 (HSPF)	(N/A)	User-defined
cool_eff		Cooling system efficiency	1.00:20.00	(N/A)	User-defined
duct_loc		Location of the majority of the ducts in the house		(N/A)	User-defined
		Conditioned space	cond		
		Unconditioned basement, unvented crawlspace	uncond_base		
		Vented crawlspace	vent_crawl		
		Unconditioned attic	uncond_attic		
		Unknown	unknown		
duct_ins		Presence of duct insulation		(N/A)	User-defined
		R-0 (no insulation)	no		
		R-6	yes		
duct_seal		Application of duct sealing	no, yes	(N/A)	User-defined
duct_eff		Duct efficiency	0.000:1.000	-	Derived from duct_loc, duct_ins, and duct_seal

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
pipe_ins		Presence of pipe insulation	no, yes	(N/A)	User-defined if heat_type = gbl, obl
tstat_type		Thermostat type		(N/A)	User-defined
		Standard	standard		
		Programmable	program		
	h_h_wd_d	Weekday daytime heating setpoint start time	0:24	hour	User-defined if tstat_type = standard
	h_h_wd_n	Weekday nighttime heating setpoint start time	0:24	hour	User-defined if tstat_type = standard
	h_h_weh_d	Weekend/holiday daytime heating setpoint start time	0:24	hour	User-defined if tstat_type = standard
	h_h_weh_n	Weekend/holiday nighttime heating setpoint start time	0:24	hour	User-defined if tstat_type = standard
	c_h_wd_d	Weekday daytime cooling setpoint start time	0:24	hour	User-defined if tstat_type = standard
	c_h_wd_n	Weekday nighttime cooling setpoint start time	0:24	hour	User-defined if tstat_type = standard
	c_h_weh_d	Weekend/holiday daytime cooling setpoint start time	0:24	hour	User-defined if tstat_type = standard
	c_h_weh_n	Weekend/holiday nighttime cooling setpoint start time	0:24	hour	User-defined if tstat_type = standard
	h_t_wd_d	Weekday daytime heating setpoint	40:100	°F	User-defined if tstat_type = standard
	h_t_wd_n	Weekday nighttime heating setpoint	40:100	°F	User-defined if tstat_type = standard
	h_t_weh_d	Weekend/holiday daytime heating setpoint	40:100	°F	User-defined if tstat_type = standard
	h_t_weh_n	Weekend/holiday nighttime heating setpoint	40:100	°F	User-defined if tstat_type = standard
	c_t_wd_d	Weekday daytime cooling setpoint	40:100	°F	User-defined if tstat_type = standard
	c_t_wd_n	Weekday nighttime cooling setpoint	40:100	°F	User-defined if tstat_type = standard

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
	c_t_weh_d	Weekend/holiday daytime cooling setpoint	40:100	°F	User-defined if tstat_type = standard
	c_t_weh_n	Weekend/holiday nighttime cooling setpoint	40:100	°F	User-defined if tstat_type = standard
	h_h_wd_w	Weekday waking time heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_wd_l	Weekday leaving time heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_wd_e	Weekday evening heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_wd_s	Weekday bedtime heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_weh_w	Weekend/holiday waking time heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_weh_l	Weekend/holiday leaving time heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_weh_e	Weekend/holiday evening heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_h_weh_s	Weekend/holiday bedtime heating setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_wd_w	Weekday waking time cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_wd_l	Weekday leaving time cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_wd_e	Weekday evening cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_wd_s	Weekday bedtime cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_weh_w	Weekend/holiday waking time cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_weh_l	Weekend/holiday leaving time cooling setpoint start time	0:24	hour	User-defined if tstat_type = program

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued*)*

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
	c_h_weh_e	Weekend/holiday evening cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	c_h_weh_s	Weekend/holiday bedtime cooling setpoint start time	0:24	hour	User-defined if tstat_type = program
	h_t_wd_w	Weekday waking time heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_wd_l	Weekday leaving time heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_wd_e	Weekday evening heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_wd_s	Weekday bedtime heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_weh_w	Weekend/holiday waking time heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_weh_l	Weekend/holiday leaving time heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_weh_e	Weekend/holiday evening heating setpoint	40:100	°F	User-defined if tstat_type = program
	h_t_weh_s	Weekend/holiday bedtime heating setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_wd_w	Weekday waking time cooling setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_wd_l	Weekday leaving time cooling setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_wd_e	Weekday evening cooling setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_wd_s	Weekday bedtime cooling setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_weh_w	Weekend/holiday waking time cooling setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_weh_l	Weekend/holiday leaving time cooling setpoint	40:100	°F	User-defined if tstat_type = program

Table 1. DOE-2 Macro Input Variables Used in the *Home Energy Saver* (continued)

Unconditional Variable Name	Conditional Variable Name	Variable Description	Range or List of Values	Units	Origin of Value
	c_t_weh_e	Weekend/holiday evening cooling setpoint	40:100	°F	User-defined if tstat_type = program
	c_t_weh_s	Weekend/holiday bedtime cooling setpoint	40:100	°F	User-defined if tstat_type = program

Table 2. Weather Data Files Used in the *Home Energy Saver*

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Alabama							
Birmingham	TMY2	33.57	-86.75	-6	630	2,985	1,991
Huntsville	TMY2	34.65	-86.77	-6	623	3,652	1,866
Mobile	TMY2	30.68	-88.25	-6	220	1,877	2,704
Montgomery	TMY2	32.30	-86.40	-6	203	2,328	2,400
Alaska							
Adak NAS	TMY	51.88	-176.65	-10	16	8,892	0
Anchorage	TMY2	61.17	-150.02	-9	115	10,331	44
Annette	TMY2	55.03	-131.57	-9	112	7,177	33
Barrow	TMY2	71.30	-156.78	-9	13	20,445	0
Bethel	TMY2	60.78	-161.80	-9	151	13,202	29
Bettles	TMY2	66.92	-151.52	-9	673	15,860	99
Big Delta	TMY2	64.00	-145.73	-9	1,273	13,600	90
Cold Bay	TMY2	55.20	-162.72	-9	95	9,515	0
Fairbanks	TMY2	64.82	-147.87	-9	453	14,274	165
Gulkana	TMY2	62.15	-145.45	-9	1,578	13,944	59
Homer	TMY	59.65	-151.48	-9	82	10,340	2
Juneau	TMY	58.35	-134.58	-9	10	9,236	15
King Salmon	TMY2	58.68	-156.65	-9	49	11,401	26
Kodiak	TMY2	57.75	-152.33	-9	112	8,859	7
Kotzebue	TMY2	66.87	-162.63	-9	16	15,787	15
McGrath	TMY2	62.97	-155.62	-9	338	14,243	60
Nome	TMY2	64.50	-165.43	-9	23	13,898	7
St. Paul Island	TMY2	57.15	-170.22	-10	23	11,022	0
Summit	TMY	63.33	-149.13	-9	2,408	14,546	11
Talkeetna	TMY2	62.30	-150.10	-9	344	11,511	60
Yakutat	TMY2	59.52	-139.67	-9	30	9,607	4

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Arizona							
Flagstaff	TMY2	35.13	-111.67	-7	7,005	7,621	458
Phoeniz	TMY2	33.43	-112.02	-7	1,112	1,483	4,515
Prescott	TMY2	34.65	-112.43	-7	5,023	4,812	1,410
Tucson	TMY2	32.12	-110.93	-7	2,556	1,956	3,331
Winslow	TMY	35.03	-110.71	-7	4,888	5,100	1,622
Yuma MCAS	TMY	32.66	-114.60	-7	203	1,122	4,660
Arkansas							
Fort Smith	TMY2	35.33	-94.37	-6	463	3,604	2,176
Little Rock	TMY2	34.73	-92.23	-6	266	3,373	2,185
California							
Arcata	TMY2	40.98	-124.10	-8	226	5,120	26
Bakersfield	TMY2	35.42	-119.05	-8	492	2,339	2,675
Barstow-Daggett	TMY2	34.87	-116.78	-8	1,929	2,134	3,305
China Lake NAF	TMY	35.68	-117.68	-8	2,218	2,695	3,388
El Centro	CTZ	32.77	-115.57	-8	-30	1,397	4,847
El Toro MCAS	TMY	33.66	-117.73	-8	381	2,090	1,065
Fresno	TMY2	36.77	-119.72	-8	328	2,933	2,304
Long Beach	TMY2	33.82	-118.15	-8	56	1,610	1,058
Los Angeles	TMY2	33.93	-118.40	-8	105	1,547	654
Mount Shasta	TMY	41.33	-122.33	-8	3,533	5,747	805
Oakland	TMY	37.71	-122.21	-8	3	3,080	202
Oxnard-Point Mugu NAWS	TMY	34.11	-119.11	-8	10	2,306	400
Pasadena	CTZ	34.15	-118.15	-8	864	2,139	1,302
Red Bluff	TMY	40.15	-122.25	-8	348	3,208	2,229
Riverside-March AFB	CTZ	33.88	-117.27	-8	1,539	2,776	1,842
Sacramento	TMY2	38.52	-121.50	-8	26	3,294	1,388
San Diego	TMY2	32.73	-117.17	-8	30	1,212	931

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
San Francisco	TMY2	37.62	-122.38	-8	16	3,518	229
Santa Maria	TMY2	34.90	-120.45	-8	236	3,736	330
Santa Rosa	CTZ	38.45	-122.72	-8	167	3,865	1,340
Sunnyvale-Moffett NAS	TMY	37.42	-122.05	-8	39	2,917	445
Colorado							
Alamosa	TMY2	37.45	-105.87	-7	7,536	9,223	422
Boulder	TMY2	40.02	-105.25	-7	5,361	6,429	995
Colorado Springs	TMY2	38.82	-104.72	-7	6,171	6,820	774
Denver-Stapleton AP	TMY	39.76	-104.86	-7	5,285	6,501	948
Eagle	TMY2	39.65	-106.92	-7	6,512	8,912	572
Grand Junction	TMY2	39.12	-108.53	-7	4,839	6,002	1,445
Pueblo	TMY2	38.28	-104.52	-7	4,721	5,683	1,435
Connecticut							
Bridgeport	TMY2	41.17	-73.13	-5	7	5,658	935
Hartford	TMY2	41.93	-72.68	-5	180	6,349	1,006
Cuba							
Guantanamo Bay NAS	TMY	19.90	-75.15	-6	56	0	5,692
Delaware							
Wilmington	TMY2	39.67	-75.60	-5	79	5,126	1,318
Florida							
Apalachicola	TMY	29.73	-85.03	-5	20	1,479	2,926
Daytona Beach	TMY2	29.18	-81.05	-5	39	997	3,067
Jacksonville	TMY2	30.50	-81.70	-5	30	1,635	2,862
Key West	TMY2	24.55	-81.75	-5	3	70	5,010
Miami	TMY2	25.80	-80.27	-5	7	203	4,431
Orlando	TMY	28.55	-81.33	-5	105	753	3,397
Tallahassee	TMY2	30.38	-84.37	-5	69	1,982	2,656
Tampa	TMY2	27.97	-82.53	-5	10	867	3,491

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
West Palm Beach	TMY2	26.68	-80.10	-5	20	301	4,063
Georgia							
Athens	TMY2	33.95	-83.32	-5	801	2,988	1,839
Atlanta	TMY2	33.65	-84.43	-5	1,033	3,210	1,784
Augusta	TMY2	33.37	-81.97	-5	148	3,159	2,022
Columbus	TMY2	32.52	-84.95	-5	446	2,565	2,367
Macon	TMY2	32.70	-83.65	-5	361	2,592	2,290
Savannah	TMY2	32.13	-81.20	-5	52	2,127	2,510
Guam							
Anderson AFB	TMY2	13.55	144.83	10	361	2	5,329
Hawaii							
Ewa-Barbers Point NAS	TMY	21.32	-158.07	-10	49	24	4,028
Hilo	TMY2	19.72	-155.07	-10	36	16	3,225
Honolulu	TMY2	21.33	-157.92	-10	16	15	4,416
Kahului	TMY2	20.90	-156.43	-10	49	42	4,068
Lihue	TMY2	21.98	-159.35	-10	148	22	3,991
Idaho							
Boise	TMY2	43.57	-116.22	-7	2,867	6,244	1,061
Lewiston	TMY	46.36	-117.01	-8	1,434	5,639	964
Pocatello	TMY2	42.92	-112.60	-7	4,478	7,509	810
Illinois							
Chicago-Midway AP	TMY	41.78	-87.75	-6	614	6,241	1,203
Chicago-O'Hare AP	TMY2	41.78	-87.75	-6	623	6,552	1,030
Moline	TMY2	41.45	-90.52	-6	594	6,404	1,190
Peoria	TMY2	40.67	-89.68	-6	653	6,437	1,177
Rockford	TMY2	42.20	-89.10	-6	725	7,023	895
Springfield	TMY2	39.83	-89.67	-6	614	5,977	1,406

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Indiana							
Evansville	TMY2	38.05	-87.53	-6	387	4,860	1,560
Fort Wayne	TMY2	41.00	-85.20	-5	827	6,523	918
Indianapolis	TMY2	39.73	-86.28	-5	807	5,846	1,177
South Bend	TMY2	41.70	-86.32	-5	774	6,363	1,052
Iowa							
Burlington	TMY	40.78	-91.13	-6	699	6,206	1,201
Des Moines	TMY2	41.53	-93.65	-6	965	6,626	1,164
Mason City	TMY2	43.15	-93.33	-6	1,224	8,309	763
Sioux City	TMY2	42.40	-96.38	-6	1,102	6,943	1,160
Waterloo	TMY2	42.55	-92.40	-6	869	7,399	821
Kansas							
Dodge City	TMY2	37.77	-99.97	-6	2,582	5,727	1,665
Goodland	TMY2	39.37	-101.70	-7	3,688	6,624	1,177
Topeka	TMY2	39.07	-95.63	-6	886	5,480	1,571
Wichita	TMY2	37.65	-97.42	-6	1,339	5,113	1,852
Kentucky							
Covington-Cincinnati AP	TMY2	39.07	-84.67	-5	889	5,322	1,265
Lexington	TMY2	38.03	-84.60	-5	988	5,064	1,217
Louisville	TMY2	38.18	-85.73	-5	489	4,552	1,577
Louisiana							
Baton Rouge	TMY2	30.53	-91.15	-6	75	1,820	2,730
Lake Charles	TMY2	30.12	-93.22	-6	10	1,855	2,796
New Orleans	TMY2	29.98	-90.25	-6	10	1,551	2,832
Shreveport	TMY2	32.47	-93.82	-6	259	2,411	2,535
Maine							
Bangor	TMY	44.80	-68.80	-5	184	8,140	449
Caribou	TMY2	46.87	-68.02	-5	623	9,568	280

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Portland	TMY2	43.65	-70.32	-5	62	7,438	521
Marshall Islands							
Kwajalein Atoll	TMY	8.73	167.73	12	7	0	6,391
Maryland							
Baltimore	TMY2	39.18	-76.67	-5	154	4,983	1,377
Patuxent River NAS	TMY	38.30	-76.41	-5	46	4,083	1,483
Massachusetts							
Boston-City WSO	TMY	42.35	-71.07	-5	20	5,894	832
Boston-Logan AP	TMY2	42.37	-71.03	-5	16	5,909	785
Worchester	TMY2	42.27	-71.87	-5	988	7,047	592
Michigan							
Alpena	TMY2	45.07	-83.57	-5	689	8,468	425
Detroit-Metro AP	TMY2	42.42	-83.02	-5	627	6,785	796
Flint	TMY2	42.97	-83.73	-5	764	7,064	720
Grand Rapids	TMY2	42.88	-85.52	-5	804	7,254	779
Houghton	TMY2	47.17	-88.50	-5	1,079	8,525	469
Lansing	TMY2	42.78	-84.60	-5	840	7,176	847
Muskegon	TMY2	43.17	-86.25	-5	627	7,071	719
Sault Ste. Marie	TMY2	46.47	-84.37	-5	725	9,231	288
Traverse City	TMY2	44.73	-85.58	-5	630	7,797	698
Minnesota							
Duluth	TMY2	46.83	-92.18	-6	1,417	10,232	315
International Falls	TMY2	48.57	-93.38	-6	1,184	10,507	339
Minneapolis-St. Paul	TMY2	44.88	-93.22	-6	837	8,037	876
Rochester	TMY2	43.92	-92.50	-6	1,319	8,331	702
St. Cloud	TMY2	45.55	-94.07	-6	1,027	9,003	665
Mississippi							
Jackson	TMY2	32.32	-90.08	-6	331	2,708	2,433

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Meridian	TMY2	32.33	-88.75	-6	308	2,898	2,292
Missouri							
Columbia	TMY2	38.82	-92.22	-6	886	5,320	1,463
Kansas City	TMY2	39.30	-94.72	-6	1,033	5,280	1,714
Springfield	TMY2	37.23	-93.38	-6	1,270	4,834	1,555
St. Louis	TMY2	38.75	-90.38	-6	564	5,179	1,712
Montana							
Billings	TMY2	45.80	-108.53	-7	3,570	7,311	882
Cut Bank	TMY2	48.60	-112.37	-7	3,839	8,783	315
Dillon	TMY	45.25	-112.55	-7	5,240	8,558	486
Glasgow	TMY2	48.22	-106.62	-7	2,297	8,901	748
Great Falls	TMY2	47.48	-111.37	-7	3,661	7,900	689
Helena	TMY2	46.60	-112.00	-7	3,898	8,085	609
Kalispell	TMY2	48.30	-114.27	-7	2,966	8,545	434
Lewistown	TMY2	47.05	-109.45	-7	4,147	8,598	566
Miles City	TMY2	46.43	-105.87	-7	2,635	8,010	907
Missoula	TMY2	46.92	-114.08	-7	3,189	8,200	642
Nebraska							
Grand Island	TMY2	40.97	-98.32	-6	1,857	6,761	1,221
Norfolk	TMY2	41.98	-97.43	-6	1,545	7,073	1,254
North Platte	TMY2	41.13	-100.68	-6	2,785	7,207	1,144
Omaha	TMY2	41.37	-96.52	-6	1,325	6,219	1,316
Scottsbluff	TMY2	41.87	-103.60	-7	3,957	6,908	1,087
Nevada							
Elko	TMY2	40.83	-115.78	-8	5,075	7,671	885
Ely	TMY2	39.28	-114.85	-8	6,253	8,384	625
Las Vegas	TMY2	36.08	-115.17	-8	2,178	2,466	3,489
Lovelock	TMY	40.06	-118.55	-8	3,898	6,189	1,346

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Reno	TMY2	39.50	-119.78	-8	4,400	6,264	1,030
Tonopah	TMY2	38.07	-117.13	-8	5,423	5,808	1,239
Winnemucca	TMY2	40.90	-117.80	-8	4,341	6,657	1,188
Yucca Flats Test Site	TMY	36.95	-116.05	-8	3,924	5,153	1,883
New Hampshire							
Concord	TMY2	43.20	-71.50	-5	344	7,682	717
New Jersey							
Atlantic City	TMY2	39.45	-74.57	-5	66	5,234	1,157
Lakehurst NAS	TMY	40.03	-74.70	-5	112	5,447	1,153
Newark	TMY2	40.70	-74.17	-5	30	5,157	1,239
New Mexico							
Albuquerque	TMY2	35.05	-106.62	-7	5,312	4,699	1,512
Clayton	TMY	36.45	-103.15	-7	4,957	5,144	1,142
Roswell	TMY	33.30	-104.53	-7	3,648	3,910	2,169
Truth or Consequences	TMY	33.23	-107.25	-7	4,849	3,822	1,850
Tucumcari	TMY2	35.18	-103.60	-7	4,039	4,301	1,723
New York							
Albany	TMY2	42.75	-73.80	-5	292	7,121	812
Binghamton	TMY2	42.22	-75.98	-5	1,637	7,546	453
Buffalo	TMY2	42.93	-78.73	-5	705	6,758	730
Massena	TMY2	44.93	-74.85	-5	207	8,468	631
New York-Central Park	TMY2	40.78	-73.97	-5	187	5,108	1,162
New York-La Guardia AP	TMY	40.78	-73.88	-5	10	4,946	1,144
Rochester	TMY2	43.12	-77.67	-5	554	6,783	841
Syracuse	TMY2	43.12	-76.12	-5	407	7,080	735
North Carolina							
Asheville	TMY2	35.43	-82.53	-5	2,169	4,746	937
Cape Hatteras	TMY2	35.27	-75.55	-5	7	2,570	1,727

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Charlotte	TMY2	35.22	-80.93	-5	768	3,496	1,732
Cherry Point MCAS	TMY	34.90	-76.88	-5	36	2,651	1,951
Greensboro	TMY2	36.08	-79.95	-5	886	4,202	1,446
Raleigh-Durham	TMY2	35.87	-78.78	-5	440	3,701	1,573
Wilmington	TMY2	34.27	-77.90	-5	30	2,794	2,130
North Dakota							
Bismarck	TMY2	46.77	-100.75	-6	1,647	8,923	728
Fargo	TMY2	46.90	-96.80	-6	899	9,201	814
Minot	TMY2	48.27	-101.28	-6	1,713	9,343	592
Ohio							
Akron	TMY2	40.92	-81.43	-5	1,237	6,310	834
Cleveland	TMY2	41.40	-81.85	-5	804	6,149	900
Columbus	TMY2	40.00	-82.88	-5	833	5,645	1,060
Dayton	TMY2	39.90	-84.22	-5	1,004	6,048	962
Mansfield	TMY2	40.82	-82.52	-5	1,296	6,281	966
Toledo	TMY2	41.60	-83.80	-5	692	6,838	911
Youngstown	TMY2	41.27	-80.67	-5	1,184	6,776	737
Oklahoma							
Oklahoma City	TMY2	35.40	-97.60	-6	1,302	3,995	2,062
Tulsa	TMY2	36.20	-95.90	-6	676	4,015	2,180
Oregon							
Astoria	TMY2	46.15	-123.88	-8	23	5,221	82
Burns	TMY2	43.58	-119.05	-8	4,170	7,396	627
Eugene	TMY2	44.12	-123.22	-8	358	5,014	574
Medford	TMY2	42.37	-122.87	-8	1,299	5,348	1,069
North Bend	TMY2	43.42	-124.25	-8	16	4,646	42
Pendleton	TMY2	45.68	-118.85	-8	1,496	5,538	1,030
Portland	TMY2	45.60	-122.60	-8	39	4,721	533

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Redmond	TMY2	44.27	-121.15	-8	3,084	6,952	656
Salem	TMY2	44.92	-123.02	-8	200	5,229	552
Palau							
Koror Island	TMY	7.33	134.48	9	92	0	6,096
Pennsylvania							
Allentown	TMY2	40.65	-75.43	-5	384	5,945	962
Bradford	TMY2	41.80	-78.63	-5	1,969	8,252	376
Erie	TMY2	42.08	-80.18	-5	738	6,785	686
Harrisburg	TMY2	40.22	-76.85	-5	348	5,568	1,225
Philadelphia	TMY2	39.88	-75.25	-5	30	5,251	1,243
Pittsburgh	TMY2	40.50	-80.22	-5	1,224	6,022	935
Wilkes Barre-Scranton	TMY2	41.33	-75.73	-5	948	6,737	766
Williamsport	TMY2	41.27	-77.05	-5	797	6,206	898
Puerto Rico							
San Juan	TMY2	18.43	-66.00	-4	62	0	5,474
Rhode Island							
Providence	TMY2	41.73	-71.43	-5	62	6,039	843
South Carolina							
Charleston	TMY2	32.90	-80.03	-5	39	2,369	2,200
Columbia	TMY2	33.95	-81.12	-5	226	3,003	2,198
Greenville-Spartanburg	TMY2	34.90	-82.22	-5	971	3,516	1,665
South Dakota							
Huron	TMY2	44.38	-98.22	-6	1,289	8,483	889
Pierre	TMY2	44.38	-100.28	-6	1,726	7,561	1,133
Rapid City	TMY2	44.05	-103.07	-7	3,169	7,579	785
Sioux Falls	TMY2	43.57	-96.73	-6	1,427	7,988	1,078
Tennessee							
Bristol	TMY2	36.48	-82.40	-5	1,506	4,521	1,091

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Chattanooga	TMY2	35.03	-85.20	-5	689	3,762	1,830
Knoxville	TMY2	35.82	-83.98	-5	981	3,817	1,549
Memphis	TMY2	35.05	-89.98	-6	285	3,175	2,312
Nashville	TMY2	36.12	-86.68	-6	591	4,130	1,978
Texas							
Abilene	TMY2	32.43	-99.68	-6	1,752	2,853	2,620
Amarillo	TMY2	35.23	-101.70	-6	3,602	5,005	1,622
Austin	TMY2	30.30	-97.70	-6	620	1,852	3,228
Beaumont-Port Arthur	TMY2	29.95	-94.02	-6	23	1,639	2,886
Brownsville	TMY2	25.90	-97.43	-6	20	779	3,811
Corpus Christi	TMY2	27.77	-97.50	-6	43	1,025	3,551
Del Rio-Laughlin AFB	TMY	29.36	-100.78	-6	1,073	1,610	3,366
El Paso	TMY2	31.80	-106.40	-7	3,917	2,781	2,655
Fort Worth	TMY2	32.83	-97.05	-6	538	2,473	2,752
Houston-Intercontinental AP	TMY2	29.98	-95.37	-6	108	1,731	3,102
Kingsville NAS	TMY	27.50	-97.82	-6	49	1,028	3,852
Laredo AFB	TMY	27.53	-99.46	-6	499	1,041	4,347
Lubbock	TMY2	33.65	-101.82	-6	3,241	3,830	1,885
Lufkin	TMY2	31.23	-94.75	-6	315	2,139	2,774
Midland-Odessa	TMY2	31.93	-102.20	-6	2,858	3,087	2,425
San Angelo	TMY	31.37	-100.50	-6	1,909	2,464	2,983
San Antonio	TMY2	29.53	-98.47	-6	794	1,828	3,192
Sherman-Perrin AFB	TMY	33.72	-96.67	-6	764	2,867	2,623
Victoria	TMY2	28.85	-96.92	-6	105	1,300	3,199
Waco	TMY2	31.62	-97.22	-6	509	2,325	2,882
Wichita Falls	TMY2	33.97	-98.48	-6	1,030	3,331	2,724
United States Minor Outlying Islands							
Wake Island	TMY	19.28	166.65	12	13	0	5,562

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Utah							
Bryce Canyon	TMY	37.70	-112.15	-7	7,585	9,421	326
Cedar City	TMY2	37.70	-113.10	-7	5,617	6,360	1,102
Salt Lake City	TMY2	40.77	-111.97	-7	4,226	5,872	1,355
Vermont							
Burlington	TMY2	44.47	-73.15	-5	341	7,872	647
Virginia							
Lynchburg	TMY2	37.33	-79.20	-5	915	4,554	1,291
Norfolk	TMY2	36.90	-76.20	-5	30	3,569	1,665
Richmond	TMY2	37.50	-77.33	-5	164	4,176	1,545
Roanoke	TMY2	37.32	-79.97	-5	1,175	4,358	1,303
Sterling-Washington, D.C.-Dulles AP	TMY2	38.95	-77.45	-5	269	5,300	1,291
Washington							
Olympia	TMY2	46.97	-122.90	-8	200	5,678	431
Quillayute	TMY2	47.95	-124.55	-8	180	5,896	92
Seattle-Tacoma	TMY2	47.45	-122.30	-8	400	5,075	306
Spokane	TMY2	47.63	-117.53	-8	2,365	7,016	684
Whidbey Island NAS	TMY	48.35	-122.66	-8	33	5,315	73
Yakima	TMY2	46.57	-120.53	-8	1,066	6,266	838
West Virginia							
Charleston	TMY2	38.37	-81.60	-5	951	4,779	1,186
Elkins	TMY2	38.88	-79.85	-5	1,949	6,472	621
Huntington	TMY2	38.37	-82.55	-5	837	4,675	1,280
Wisconsin							
Eau Claire	TMY2	44.87	-91.48	-6	896	8,598	757
Green Bay	TMY2	44.48	-88.13	-6	702	8,343	665
La Crosse	TMY2	43.87	-91.25	-6	673	7,768	869
Madison	TMY2	43.13	-89.33	-6	860	7,535	816

Table 2. Weather Data Files Used in the *Home Energy Saver* (continued)

Location	File Type	Latitude (°)	Longitude (°)	Time Zone (h)	Elevation (ft)	Heating Degree-Days (°F-days)	Cooling Degree-Days (°F-days)
Milwaukee	TMY2	42.95	-87.90	-6	692	7,572	671
Wyoming							
Casper	TMY2	42.92	-106.47	-7	5,289	7,991	713
Cheyenne	TMY2	41.15	-104.82	-7	6,142	7,616	587
Lander	TMY2	42.82	-108.73	-7	5,564	8,056	684
Rock Springs	TMY2	41.60	-109.07	-7	6,745	8,666	548
Sheridan	TMY2	44.77	-106.97	-7	3,967	7,938	766

Table 3. Construction Materials Modeled in the *Home Energy Saver*

Construction Material Type	Thickness (in)	Density (lb/ft^3)	Specific Heat (Btu/lb·°F)	Conductance ($Btu/h \cdot ft^2 \cdot °F$)	Data Source	DOE-2 Code Name
Damp soil	6.000	115.0000	0.2800	1.0000	Winkelmann (1998)	dampsoil
Poured concrete	(Variable)	140.0000	0.2150	0.9250	ASHRAE (2001a)	conc140
Lightweight concrete block	8.000	79.0000	0.2100	0.2867	ASHRAE (2001a)	concbllw
Common structural brick	8.000	150.0000	0.1900	0.7750	ASHRAE (2001a)	brik
Pine or fir beam	(Variable)	27.9500	0.3900	0.0683	ASHRAE (2001a)	woodbeam
Wood underlayment	0.750	40.0000	0.2900	0.0635	ASHRAE (2001a)	woodund
Wood subfloor[a]	0.750	40.0000	0.3300	0.0663	ASHRAE (2001a)	woodsub
Fiberboard sheathing	0.500	18.0000	0.3100	0.0317	ASHRAE (2001a)	fibrshth
Plywood sheathing	(Variable)	34.0000	0.2900	0.0667	ASHRAE (2001a)	plywshth
Lapped wood siding[b]	0.500	18.0000	0.2800	0.0513	ASHRAE (2001a)	woodsid
Stucco finish	1.000	100.0000	0.2100	0.5583	ASHRAE (2001a)	stucsid
Vinyl siding[c]	0.125	30.0000	0.2900	0.0171	ASHRAE (2001a)	vinlsid
Aluminum siding	0.125	171.0000	0.2140	0.0171	ASHRAE (2001a)	alumsid
Face brick veneer	4.000	110.0000	0.1900	0.4500	ASHRAE (2001a)	briksid
Asphalt composition roof shingle	0.250	70.0000	0.3000	0.0473	ASHRAE (2001a)	comproof
Wood roof shake[b]	0.250	18.0000	0.2800	0.0175	ASHRAE (2001a)	woodroof
Clay roof tile[d]	0.500	110.0000	0.2100	0.3125	ASHRAE (2001a)	clayroof
Lightweight concrete roof tile	0.250	79.0000	0.2100	0.2867	ASHRAE (2001a)	concroof
Tar roofing	0.375	70.0000	0.3500	0.0938	ASHRAE (2001a)	tarroof
Gravel roofing	0.500	55.0000	0.4000	0.8333	Winkelmann et al. (1993a)	gravroof
Gypsum wallboard	0.500	50.0000	0.2600	0.0925	ASHRAE (2001a)	gypboard
Carpet and fibrous pad[e]	0.500	18.0000	0.3400	0.0200	ASHRAE (2001a)	carppad
Felt building membrane[b, f, g]	0.125	10.0000	0.3400	0.1740	ASHRAE (2001a)	feltmem
Straw bale	23.000	11.1652	0.2991	0.0347	U.S. DOE (1995)	strwbale
R-3 mineral fiber batt insulation[h]	1.000	1.2000	0.1700	0.0278	ASHRAE (2001a)	mbatin03
R-7 mineral fiber batt insulation[h]	2.000	1.2000	0.1700	0.0238	ASHRAE (2001a)	mbatin07
R-11 mineral fiber batt insulation[h]	3.500	1.2000	0.1700	0.0265	ASHRAE (2001a)	mbatin11
R-13 mineral fiber batt insulation[h]	3.500	1.2000	0.1700	0.0224	ASHRAE (2001a)	mbatin13
R-15 mineral fiber batt insulation[h]	3.500	1.4000	0.1700	0.0194	ASHRAE (2001a)	mbatin15
R-19 mineral fiber batt insulation[h]	5.500	1.2000	0.1700	0.0241	ASHRAE (2001a)	mbatin19
R-21 mineral fiber batt insulation[h]	5.500	0.8000	0.1700	0.0218	ASHRAE (2001a)	mbatin21
R-25 mineral fiber batt insulation[h]	7.000	1.2000	0.1700	0.0233	ASHRAE (2001a)	mbatin25

Table 3. Construction Materials Modeled in the *Home Energy Saver* (continued)

Construction Material Type	Thickness (in)	Density (lb/ft^3)	Specific Heat (Btu/lb·°F)	Conductance ($Btu/h \cdot ft^2 \cdot °F$)	Data Source	DOE-2 Code Name
R-27 mineral fiber batt insulation[h]	7.500	1.2000	0.1700	0.0231	ASHRAE (2001a)	mbatin27
R-30 mineral fiber batt insulation[h]	8.500	1.2000	0.1700	0.0236	ASHRAE (2001a)	mbatin30
R-33 mineral fiber batt insulation[h]	9.500	1.2000	0.1700	0.0240	ASHRAE (2001a)	mbatin33
R-38 mineral fiber batt insulation[h]	11.500	1.2000	0.1700	0.0252	ASHRAE (2001a)	mbatin38
R-2.8 fiberglass fill wall insulation	0.750	2.7500	0.1700	0.0223	ASHRAE (2001a)	fwalin03
R-5.6 fiberglass fill wall insulation	1.750	2.7500	0.1700	0.0260	ASHRAE (2001a)	fwalin06
R-3 fiberglass fill ceiling insulation	1.000	1.3000	0.1700	0.0278	ASHRAE (2001a)	ffilin03
R-6 fiberglass fill ceiling insulation	2.000	1.3000	0.1700	0.0278	ASHRAE (2001a)	ffilin06
R-9 fiberglass fill ceiling insulation	3.000	1.3000	0.1700	0.0278	ASHRAE (2001a)	ffilin09
R-11 fiberglass fill ceiling insulation	3.500	1.3000	0.1700	0.0265	ASHRAE (2001a)	ffilin11
R-19 fiberglass fill ceiling insulation	6.500	1.3000	0.1700	0.0285	ASHRAE (2001a)	ffilin19
R-21 fiberglass fill ceiling insulation	7.500	1.3000	0.1700	0.0298	ASHRAE (2001a)	ffilin21
R-25 fiberglass fill ceiling insulation	9.000	1.3000	0.1700	0.0300	ASHRAE (2001a)	ffilin25
R-30 fiberglass fill ceiling insulation	10.500	1.3000	0.1700	0.0292	ASHRAE (2001a)	ffilin30
R-38 fiberglass fill ceiling insulation	13.000	1.3000	0.1700	0.0285	ASHRAE (2001a)	ffilin38
R-44 fiberglass fill ceiling insulation	15.000	1.3000	0.1700	0.0284	ASHRAE (2001a)	ffilin44
R-49 fiberglass fill ceiling insulation	16.500	1.3000	0.1700	0.0281	ASHRAE (2001a)	ffilin49
R-60 fiberglass fill ceiling insulation	20.000	1.3000	0.1700	0.0278	ASHRAE (2001a)	ffilin60
Expanded polystyrene sheathing	(Variable)	2.6500	0.2900	0.0167	ASHRAE (2001a)	epsin05
Radiant barrier[i]	3.500	0.0750	0.2400	0.0911	ASHRAE (2001a)	radbar
0.75-in vertical air space	0.750	0.0750	0.2400	0.0694	Winkelmann et al. (1993a)	vair0075
1.50-in vertical air space	1.500	0.0750	0.2400	0.1404	Winkelmann et al. (1993a)	vair0150
1.75-in vertical air space	1.750	0.0750	0.2400	0.1639	Winkelmann et al. (1993a)	vair0175
2.00-in vertical air space	2.000	0.0750	0.2400	0.1873	Winkelmann et al. (1993a)	vair0200
2.50-in vertical air space	2.500	0.0750	0.2400	0.2341	Winkelmann et al. (1993a)	vair0250
3.50-in vertical air space	3.500	0.0750	0.2400	0.3277	Winkelmann et al. (1993a)	vair0350
5.00-in vertical air space	5.000	0.0750	0.2400	0.4529	Winkelmann et al. (1993a)	vair0500
2.00-in sloped air space	2.000	0.0750	0.2400	0.1916	Winkelmann et al. (1993a)	sair0200
3.50-in sloped air space	3.500	0.0750	0.2400	0.3352	Winkelmann et al. (1993a)	sair0350
0.50-in horizontal air space	0.500	0.0750	0.2400	0.0508	Winkelmann et al. (1993a)	hair0050
1.50-in horizontal air space	1.500	0.0750	0.2400	0.1437	Winkelmann et al. (1993a)	hair0150
2.50-in horizontal air space	2.500	0.0750	0.2400	0.2395	Winkelmann et al. (1993a)	hair0250

Table 3. Construction Materials Modeled in the *Home Energy Saver* (continued)

Construction Material Type	Thickness (in)	Density (lb/ft^3)	Specific Heat (Btu/lb·°F)	Conductance (Btu/h·ft^2·°F)	Data Source	DOE-2 Code Name
3.00-in horizontal air space	3.000	0.0750	0.2400	0.2874	Winkelmann et al. (1993a)	hair0300
3.50-in horizontal air space	3.500	0.0750	0.2400	0.3352	Winkelmann et al. (1993a)	hair0350
4.50-in horizontal air space	4.500	0.0750	0.2400	0.4076	Winkelmann et al. (1993a)	hair0450
5.75-in horizontal air space	5.750	0.0750	0.2400	0.5208	Winkelmann et al. (1993a)	hair0575
6.00-in horizontal air space	6.000	0.0750	0.2400	0.5435	Winkelmann et al. (1993a)	hair0600
8.00-in horizontal air space	8.000	0.0750	0.2400	0.7246	Winkelmann et al. (1993a)	hair0800
11.50-in horizontal air space	11.500	0.0750	0.2400	1.0417	Winkelmann et al. (1993a)	hair1150

[a]The density of wood subfloors is assumed similar to that of wood underlayments.
[b]The densities of vinyl siding and felt building membranes are estimated.
[c]The densities of lapped wood siding and wood roof shakes are assumed similar to that of fiberboard sheathing.
[d]The density of clay roof tile is assumed similar to that of face brick veneer.
[e]The density of carpets and pads is assumed similar to that of fiberboard sheathing.
[f]A measurable thickness is assigned to felt building membranes to prevent WALFERF errors.
[g]The specific heat of felt building membranes is assumed similar to that of carpets and pads.
[h]The specific heat of mineral fiber batt insulation is assumed similar to that of fiberglass fill ceiling insulation.
[i]An equivalent air space is used to represent radiant barriers as material layers of measurable thickness to prevent WALFERF errors.

Table 4. Constructions Modeled in the *Home Energy Saver*

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
Slab-on-Grade Floors				
1	(1) Fictitious insulation	(N/A)	0 or 5	sflrcon
	(2) 6-in damp soil			
	(3) 4-in poured concrete			
	(4) 0.5-in carpet and fibrous pad			
Basement Floors				
2	(1) Fictitious insulation	(N/A)	0	bflrcon
	(2) 6-in damp soil			
	(3) 4-in poured concrete			
Raised Basement Floors				
3	(Refer to construction no. 2)	(N/A)	0	bflrrcon
Crawlspace Floors				
4	(1) Fictitious insulation	(N/A)	0	cflrcon
	(2) 6-in damp soil			
Basement Walls below Grade				
5	(1) Fictitious insulation	(N/A)	0	bbwallcon
	(2) 6-in damp soil			
	(3) 10-in poured concrete			
6	(1) Fictitious insulation	(N/A)	11	bbwallcon
	(2) 6-in damp soil			
	(3) 10-in poured concrete			
	(4) 4-in (R-11) mineral fiber batt insulation			
7	(1) Fictitious insulation	(N/A)	19	bbwallcon
	(2) 6-in damp soil			
	(3) 10-in poured concrete			
	(4) 6-in (R-19) mineral fiber batt insulation			
Raised Basement Walls below Grade				
8	(Refer to construction no. 5)	(N/A)	0	bbwallrcn

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
9	(Refer to construction no. 6)	(N/A)	11	bbwallrcn
10	(Refer to construction no. 7)	(N/A)	19	bbwallrcn
Basement or Crawlspace Walls above Grade				
11	(1) 10-in poured concrete	(N/A)	0	bawallcon
12	(1) 10-in poured concrete	(N/A)	11	bawallcon
	(2) 4-in (R-11) mineral fiber batt insulation			
13	(1) 10-in poured concrete	(N/A)	19	bawallcon
	(2) 6-in (R-19) mineral fiber batt insulation			
Raised Basement Walls above Grade				
14	(Refer to construction no. 11)	(N/A)	0	bawallrcn
15	(Refer to construction no. 12)	(N/A)	11	bawallrcn
16	(Refer to construction no. 13)	(N/A)	19	bawallrcn
Floors above Basements and Crawlspaces				
17	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	0	efwf00ca
	(1b) 11.5-in horizontal air spaces			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
18	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	11	efwf11ca
	(1b) 8-in horizontal air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
19	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	13	efwf13ca
	(1b) 8-in horizontal air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
20	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	15	efwf15ca
	(1b) 8-in horizontal air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
21	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	19	efwf19ca
	(1b) 6-in horizontal air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
22	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	21	efwf21ca
	(1b) 6-in horizontal air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
23	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	25	efwf25ca
	(1b) 4-in horizontal air spaces + 7.5-in (R-25) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
24	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	30	efwf30ca
	(1b) 2-in horizontal air spaces + 9.5-in (R-30) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
25	(1a) 11.5-in wood floor joists @ 24 in o.c.	10.0	38	efwf38ca
	(1b) 11.5-in (R-30) mineral fiber batt insulation			
	(2) 0.75-in wood underlayment			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
Wood Frame Walls				
26	(1) 0.5-in lapped wood siding	25.0	0	ewwf00wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			
27	(1) 1-in stucco finish	25.0	0	ewwf00st
	(2) 0.625-in plywood sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			
28	(1) 0.125-in vinyl siding	25.0	0	ewwf00vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			
29	(1) 0.125-in aluminum siding	25.0	0	ewwf00al
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			
30	(1) 4-in face brick veneer	25.0	0	ewwf00br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 3.5-in wood studs @ 16 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(4b) 3.5-in vertical air spaces			
	(5) 0.5-in gypsum wallboard			
31	(1) 0.5-in lapped wood siding	25.0	3	ewwf03wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
32	(1) 1-in stucco finish	25.0	3	ewwf03st
	(2) 0.625-in plywood sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
33	(1) 0.125-in vinyl siding	25.0	3	ewwf03vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
34	(1) 0.125-in aluminum siding	25.0	3	ewwf03al
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
35	(1) 4-in face brick veneer	25.0	3	ewwf03br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(5) 0.5-in gypsum wallboard			
36	(1) 0.5-in lapped wood siding	25.0	7	ewwf07wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 1.5-in X 3.5-in wood studs @ 16 in o.c.			
	(3b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
37	(1) 1-in stucco finish	25.0	7	ewwf07st
	(2) 0.625-in plywood sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
38	(1) 0.125-in vinyl siding	25.0	7	ewwf07vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
39	(1) 0.125-in aluminum siding	25.0	7	ewwf07al
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
40	(1) 4-in face brick veneer	25.0	7	ewwf07br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
41	(1) 0.5-in lapped wood siding	25.0	11	ewwf11wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-11) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
42	(1) 1-in stucco finish	25.0	11	ewwf11st
	(2) 0.625-in plywood sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-11) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
43	(1) 0.125-in vinyl siding	25.0	11	ewwf11vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-11) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
44	(1) 0.125-in aluminum siding	25.0	11	ewwf11al
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-11) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
45	(1) 4-in face brick veneer	25.0	11	ewwf11br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
46	(1) 0.5-in lapped wood siding	25.0	13	ewwf13wo

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-13) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
47	(1) 1-in stucco finish	25.0	13	ewwf13st
	(2) 0.625-in plywood sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-13) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
48	(1) 0.125-in vinyl siding	25.0	13	ewwf13vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-13) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
49	(1) 0.125-in aluminum siding	25.0	13	ewwf13al
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-13) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
50	(1) 4-in face brick veneer	25.0	13	ewwf13br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
51	(1) 0.5-in lapped wood siding	25.0	15	ewwf15wo
	(2) 0.5-in fiberboard sheathing			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-15) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
52	(1) 1-in stucco finish	25.0	15	ewwf15st
	(2) 0.625-in plywood sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-15) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
53	(1) 0.125-in vinyl siding	25.0	15	ewwf15vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-15) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
54	(1) 0.125-in aluminum siding	25.0	15	ewwf15al
	(2) 0.5-in fiberboard sheathing			
	(3a) 3.5-in wood studs @ 16 in o.c.			
	(3b) 3.5-in (R-15) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
55	(1) 4-in face brick veneer	25.0	15	ewwf15br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
56	(1) 0.5-in lapped wood siding	25.0	19	ewwf19wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
57	(1) 1-in stucco finish	25.0	19	ewwf19st
	(2) 0.625-in plywood sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
58	(1) 0.125-in vinyl siding	25.0	19	ewwf19vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
59	(1) 0.125-in aluminum siding	25.0	19	ewwf19al
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
60	(1) 4-in face brick veneer	25.0	19	ewwf19br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
61	(1) 0.5-in lapped wood siding	25.0	21	ewwf21wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(4) 0.5-in gypsum wallboard			
62	(1) 1-in stucco finish	25.0	21	ewwf21st
	(2) 0.625-in plywood sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
63	(1) 0.125-in vinyl siding	25.0	21	ewwf21vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
64	(1) 0.125-in aluminum siding	25.0	21	ewwf21al
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 16 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
65	(1) 4-in face brick veneer	25.0	21	ewwf21br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
Wood Frame Walls with Insulated Headers				
66	(Refer to construction no. 26)	22.5	0	ewih00wo
67	(Refer to construction no. 27)	22.5	0	ewih00st
68	(Refer to construction no. 28)	22.5	0	ewih00vi
69	(Refer to construction no. 29)	22.5	0	ewih00al

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
70	(Refer to construction no. 30)	22.5	0	ewih00br
71	(Refer to construction no. 31)	22.5	3	ewih03wo
72	(Refer to construction no. 32)	22.5	3	ewih03st
73	(Refer to construction no. 33)	22.5	3	ewih03vi
74	(Refer to construction no. 34)	22.5	3	ewih03al
75	(Refer to construction no. 35)	22.5	3	ewih03br
76	(Refer to construction no. 36)	22.5	7	ewih07wo
77	(Refer to construction no. 37)	22.5	7	ewih07st
78	(Refer to construction no. 38)	22.5	7	ewih07vi
79	(Refer to construction no. 39)	22.5	7	ewih07al
80	(Refer to construction no. 40)	22.5	7	ewih07br
81	(Refer to construction no. 41)	22.5	11	ewih11wo
82	(Refer to construction no. 42)	22.5	11	ewih11st
83	(Refer to construction no. 43)	22.5	11	ewih11vi
84	(Refer to construction no. 44)	22.5	11	ewih11al
85	(Refer to construction no. 45)	22.5	11	ewih11br
86	(Refer to construction no. 46)	22.5	13	ewih13wo
87	(Refer to construction no. 47)	22.5	13	ewih13st
88	(Refer to construction no. 48)	22.5	13	ewih13vi
89	(Refer to construction no. 49)	22.5	13	ewih13al
90	(Refer to construction no. 50)	22.5	13	ewih13br
91	(Refer to construction no. 51)	22.5	15	ewih15wo
92	(Refer to construction no. 52)	22.5	15	ewih15st
93	(Refer to construction no. 53)	22.5	15	ewih15vi
94	(Refer to construction no. 54)	22.5	15	ewih15al
95	(Refer to construction no. 55)	22.5	15	ewih15br
96	(Refer to construction no. 56)	22.5	19	ewih19wo
97	(Refer to construction no. 57)	22.5	19	ewih19st

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
98	(Refer to construction no. 58)	22.5	19	ewih19vi
99	(Refer to construction no. 59)	22.5	19	ewih19al
100	(Refer to construction no. 60)	22.5	19	ewih19br
101	(Refer to construction no. 61)	22.5	21	ewih21wo
102	(Refer to construction no. 62)	22.5	21	ewih21st
103	(Refer to construction no. 63)	22.5	21	ewih21vi
104	(Refer to construction no. 64)	22.5	21	ewih21al
105	(Refer to construction no. 65)	22.5	21	ewih21br
Wood Frame Walls with Expanded Polystyrene Sheathing				
106	(1) 0.5-in lapped wood siding	25.0	0 + 5	ewps00wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in vertical air spaces			
	(5) 0.5-in gypsum wallboard			
107	(1) 1-in stucco finish	25.0	0 + 5	ewps00st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in vertical air spaces			
	(5) 0.5-in gypsum wallboard			
108	(1) 0.125-in vinyl siding	25.0	0 + 5	ewps00vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in vertical air spaces			
	(5) 0.5-in gypsum wallboard			
109	(1) 0.125-in aluminum siding	25.0	0 + 5	ewps00al

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in vertical air spaces			
	(5) 0.5-in gypsum wallboard			
110	(1) 4-in face brick veneer	25.0	0 + 5	ewps00br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 3.5-in wood studs @ 16 in o.c.			
	(5b) 3.5-in vertical air spaces			
	(6) 0.5-in gypsum wallboard			
111	(1) 0.5-in lapped wood siding	25.0	3 + 5	ewps03wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
112	(1) 1-in stucco finish	25.0	3 + 5	ewps03st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
113	(1) 0.125-in vinyl siding	25.0	3 + 5	ewps03vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
114	(1) 0.125-in aluminum siding	25.0	3 + 5	ewps03al
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
115	(1) 4-in face brick veneer	25.0	3 + 5	ewps03br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 3.5-in wood studs @ 16 in o.c.			
	(5b) 2.5-in vertical air spaces + 1-in (R-3) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
116	(1) 0.5-in lapped wood siding	25.0	7 + 5	ewps07wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
117	(1) 1-in stucco finish	25.0	7 + 5	ewps07st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(5) 0.5-in gypsum wallboard			
118	(1) 0.125-in vinyl siding	25.0	7 + 5	ewps07vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
119	(1) 0.125-in aluminum siding	25.0	7 + 5	ewps07al
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
120	(1) 4-in face brick veneer	25.0	7 + 5	ewps07br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 3.5-in wood studs @ 16 in o.c.			
	(5b) 1.5-in vertical air spaces + 2-in (R-7) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
121	(1) 0.5-in lapped wood siding	25.0	11 + 5	ewps11wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
122	(1) 1-in stucco finish	25.0	11 + 5	ewps11st

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
123	(1) 0.125-in vinyl siding	25.0	11 + 5	ewps11vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
124	(1) 0.125-in aluminum siding	25.0	11 + 5	ewps11al
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
125	(1) 4-in face brick veneer	25.0	11 + 5	ewps11br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 3.5-in wood studs @ 16 in o.c.			
	(5b) 3.5-in (R-11) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
126	(1) 0.5-in lapped wood siding	25.0	13 + 5	ewps13wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
127	(1) 1-in stucco finish	25.0	13 + 5	ewps13st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
128	(1) 0.125-in vinyl siding	25.0	13 + 5	ewps13vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
129	(1) 0.125-in aluminum siding	25.0	13 + 5	ewps13al
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
130	(1) 4-in face brick veneer	25.0	13 + 5	ewps13br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 3.5-in wood studs @ 16 in o.c.			
	(5b) 3.5-in (R-13) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(6) 0.5-in gypsum wallboard			
131	(1) 0.5-in lapped wood siding	25.0	15 + 5	ewps15wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
132	(1) 1-in stucco finish	25.0	15 + 5	ewps15st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
133	(1) 0.125-in vinyl siding	25.0	15 + 5	ewps15vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
134	(1) 0.125-in aluminum siding	25.0	15 + 5	ewps15al
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 3.5-in wood studs @ 16 in o.c.			
	(4b) 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
135	(1) 4-in face brick veneer	25.0	15 + 5	ewps15br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 3.5-in wood studs @ 16 in o.c.			
	(5b) 3.5-in (R-15) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
136	(1) 0.5-in lapped wood siding	25.0	19 + 5	ewps19wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
137	(1) 1-in stucco finish	25.0	19 + 5	ewps19st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
138	(1) 0.125-in vinyl siding	25.0	19 + 5	ewps19vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
139	(1) 0.125-in aluminum siding	25.0	19 + 5	ewps19al
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-19) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(5) 0.5-in gypsum wallboard			
140	(1) 4-in face brick veneer	25.0	19 + 5	ewps19br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 5.5-in wood studs @ 16 in o.c.			
	(5b) 5.5-in (R-19) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
141	(1) 0.5-in lapped wood siding	25.0	21 + 5	ewps21wo
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
142	(1) 1-in stucco finish	25.0	21 + 5	ewps21st
	(2) 0.625-in plywood sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
143	(1) 0.125-in vinyl siding	25.0	21 + 5	ewps21vi
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
144	(1) 0.125-in aluminum siding	25.0	21 + 5	ewps21al

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.5-in fiberboard sheathing			
	(3) 1-in expanded polystyrene insulation			
	(4a) 5.5-in wood studs @ 16 in o.c.			
	(4b) 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
145	(1) 4-in face brick veneer	25.0	21 + 5	ewps21br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 1-in expanded polystyrene insulation			
	(4) 0.5-in plywood sheathing			
	(5a) 5.5-in wood studs @ 16 in o.c.			
	(5b) 5.5-in (R-21) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
Wood Frame Walls with Insulated Headers and Expanded Polystyrene Sheathing				
146	(Refer to construction no. 121)	22.5	11 + 5	ewph11wo
147	(Refer to construction no. 122)	22.5	11 + 5	ewph11st
148	(Refer to construction no. 123)	22.5	11 + 5	ewph11vi
149	(Refer to construction no. 124)	22.5	11 + 5	ewph11al
150	(Refer to construction no. 125)	22.5	11 + 5	ewph11br
151	(Refer to construction no. 126)	22.5	13 + 5	ewph13wo
152	(Refer to construction no. 127)	22.5	13 + 5	ewph13st
153	(Refer to construction no. 128)	22.5	13 + 5	ewph13vi
154	(Refer to construction no. 129)	22.5	13 + 5	ewph13al
155	(Refer to construction no. 130)	22.5	13 + 5	ewph13br
156	(Refer to construction no. 131)	22.5	15 + 5	ewph15wo
157	(Refer to construction no. 132)	22.5	15 + 5	ewph15st
158	(Refer to construction no. 133)	22.5	15 + 5	ewph15vi
159	(Refer to construction no. 134)	22.5	15 + 5	ewph15al

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
160	(Refer to construction no. 135)	22.5	15 + 5	ewph15br
161	(Refer to construction no. 136)	22.5	19 + 5	ewph19wo
162	(Refer to construction no. 137)	22.5	19 + 5	ewph19st
163	(Refer to construction no. 138)	22.5	19 + 5	ewph19vi
164	(Refer to construction no. 139)	22.5	19 + 5	ewph19al
165	(Refer to construction no. 140)	22.5	19 + 5	ewph19br
166	(Refer to construction no. 141)	22.5	21 + 5	ewph21wo
167	(Refer to construction no. 142)	22.5	21 + 5	ewph21st
168	(Refer to construction no. 143)	22.5	21 + 5	ewph21vi
169	(Refer to construction no. 144)	22.5	21 + 5	ewph21al
170	(Refer to construction no. 145)	22.5	21 + 5	ewph21br
Wood Frame Walls with Expanded Polystyrene Sheathing and Optimum Value Engineering				
171	(Refer to construction no. 181)	12.5	19 + 5	ewop19wo
172	(Refer to construction no. 182)	12.5	19 + 5	ewop19st
173	(Refer to construction no. 183)	12.5	19 + 5	ewop19vi
174	(Refer to construction no. 184)	12.5	19 + 5	ewop19al
175	(Refer to construction no. 185)	12.5	19 + 5	ewop19br
176	(Refer to construction no. 186)	12.5	21 + 5	ewop21wo
177	(Refer to construction no. 187)	12.5	21 + 5	ewop21st
178	(Refer to construction no. 188)	12.5	21 + 5	ewop21vi
179	(Refer to construction no. 189)	12.5	21 + 5	ewop21al
180	(Refer to construction no. 190)	12.5	21 + 5	ewop21br
Wood Frame Walls with Optimum Value Engineering				
181	(1) 0.5-in lapped wood siding	12.5	19	ewov19wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
182	(1) 1-in stucco finish	12.5	19	ewov19st
	(2) 0.625-in plywood sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
183	(1) 0.125-in vinyl siding	12.5	19	ewov19vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
184	(1) 0.125-in aluminum siding	12.5	19	ewov19al
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-19) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
185	(1) 4-in face brick veneer	12.5	19	ewov19br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 5.5-in wood studs @ 24 in o.c.			
	(4b) 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
186	(1) 0.5-in lapped wood siding	12.5	21	ewov21wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
187	(1) 1-in stucco finish	12.5	21	ewov21st

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.625-in plywood sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
188	(1) 0.125-in vinyl siding	12.5	21	ewov21vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
189	(1) 0.125-in aluminum siding	12.5	21	ewov21al
	(2) 0.5-in fiberboard sheathing			
	(3a) 5.5-in wood studs @ 24 in o.c.			
	(3b) 5.5-in (R-21) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
190	(1) 4-in face brick veneer	12.5	21	ewov21br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 5.5-in wood studs @ 24 in o.c.			
	(4b) 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
191	(1) 0.5-in lapped wood siding	12.5	27	ewov27wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 7.5-in wood studs @ 24 in o.c.			
	(3b) 7.5-in (R-27) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
192	(1) 1-in stucco finish	12.5	27	ewov27st
	(2) 0.625-in plywood sheathing			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(3a) 7.5-in wood studs @ 24 in o.c.			
	(3b) 7.5-in (R-27) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
193	(1) 0.125-in vinyl siding	12.5	27	ewov27vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 7.5-in wood studs @ 24 in o.c.			
	(3b) 7.5-in (R-27) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
194	(1) 0.125-in aluminum siding	12.5	27	ewov27al
	(2) 0.5-in fiberboard sheathing			
	(3a) 7.5-in wood studs @ 24 in o.c.			
	(3b) 7.5-in (R-27) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
195	(1) 4-in face brick veneer	12.5	27	ewov27br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 7.5-in wood studs @ 24 in o.c.			
	(4b) 7.5-in (R-27) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
196	(1) 0.5-in lapped wood siding	12.5	33	ewov33wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 9.5-in wood studs @ 24 in o.c.			
	(3b) 9.5-in (R-33) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
197	(1) 1-in stucco finish	12.5	33	ewov33st
	(2) 0.625-in plywood sheathing			
	(3a) 9.5-in wood studs @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(3b) 9.5-in (R-33) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
198	(1) 0.125-in vinyl siding	12.5	33	ewov33vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 9.5-in wood studs @ 24 in o.c.			
	(3b) 9.5-in (R-33) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
199	(1) 0.125-in aluminum siding	12.5	33	ewov33al
	(2) 0.5-in fiberboard sheathing			
	(3a) 9.5-in wood studs @ 24 in o.c.			
	(3b) 9.5-in (R-33) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
200	(1) 4-in face brick veneer	12.5	33	ewov33br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 9.5-in wood studs @ 24 in o.c.			
	(4b) 9.5-in (R-33) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
201	(1) 0.5-in lapped wood siding	12.5	38	ewov38wo
	(2) 0.5-in fiberboard sheathing			
	(3a) 11.5-in wood studs @ 24 in o.c.			
	(3b) 11.5-in (R-38) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
202	(1) 1-in stucco finish	12.5	38	ewov38st
	(2) 0.625-in plywood sheathing			
	(3a) 11.5-in wood studs @ 24 in o.c.			
	(3b) 11.5-in (R-38) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(4) 0.5-in gypsum wallboard			
203	(1) 0.125-in vinyl siding	12.5	38	ewov38vi
	(2) 0.5-in fiberboard sheathing			
	(3a) 11.5-in wood studs @ 24 in o.c.			
	(3b) 11.5-in (R-38) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
204	(1) 0.125-in aluminum siding	12.5	38	ewov38al
	(2) 0.5-in fiberboard sheathing			
	(3a) 11.5-in wood studs @ 24 in o.c.			
	(3b) 11.5-in (R-38) mineral fiber batt insulation			
	(4) 0.5-in gypsum wallboard			
205	(1) 4-in face brick veneer	12.5	38	ewov38br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in plywood sheathing			
	(4a) 11.5-in wood studs @ 24 in o.c.			
	(4b) 11.5-in (R-38) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
Structural Brick Walls				
206	(1) 8-in common structural brick	(N/A)	0	ewbr00nn
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in gypsum wallboard			
207	(1) 8-in common structural brick	(N/A)	5	ewbr05nn
	(2) 1-in expanded polystyrene insulation			
	(3a) 0.75-in wood furring			
	(3b) 0.75-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
208	(1) 8-in common structural brick	(N/A)	10	ewbr10nn
	(2) 2-in expanded polystyrene insulation			
	(3a) 0.75-in wood furring			
	(3b) 0.75-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			
Concrete Block Walls				
209	(1) 1-in stucco finish	(N/A)	0	ewcb00st
	(2a) 8-in concrete block			
	(2b) 5-in vertical air spaces			
	(3a) 0.75-in wood furring			
	(3b) 0.75-in vertical air spaces			
	(4) 0.5-in gypsum wallboard			
210	(1) 4-in face brick veneer	(N/A)	0	ewcb00br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3a) 8-in concrete block			
	(3b) 5-in vertical air spaces			
	(4a) 0.75-in wood furring			
	(4b) 0.75-in vertical air spaces			
	(5) 0.5-in gypsum wallboard			
211	(1a) 8-in concrete block	(N/A)	0	ewcb00nn
	(1b) 5-in vertical air spaces			
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3) 0.5-in gypsum wallboard			
212	(1) 1-in stucco finish	(N/A)	2.8	ewcb03st
	(2a) 8-in concrete block			
	(2b) 5-in vertical air spaces			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(3a) 0.75-in wood furring			
	(3b) 0.75-in (R-2.8) fiberglass fill wall insulation			
	(4) 0.5-in gypsum wallboard			
213	(1) 4-in face brick veneer	(N/A)	2.8	ewcb03br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3a) 8-in concrete block			
	(3b) 5-in vertical air spaces			
	(4a) 0.75-in wood furring			
	(4b) 0.75-in (R-2.8) fiberglass fill wall insulation			
	(5) 0.5-in gypsum wallboard			
214	(1a) 8-in concrete block	(N/A)	2.8	ewcb03nn
	(1b) 5-in vertical air spaces			
	(2a) 0.75-in wood furring			
	(2b) 0.75-in (R-2.8) fiberglass fill wall insulation			
	(3) 0.5-in gypsum wallboard			
215	(1) 1-in stucco finish	(N/A)	5.6	ewcb06st
	(2a) 8-in concrete block			
	(2b) 5-in vertical air spaces			
	(3a) 1.75-in wood furring			
	(3b) 1.75-in (R-5.6) fiberglass fill wall insulation			
	(4) 0.5-in gypsum wallboard			
216	(1) 4-in face brick veneer	(N/A)	5.6	ewcb06br
	(2a) 0.75-in wood furring			
	(2b) 0.75-in vertical air spaces			
	(3a) 8-in concrete block			
	(3b) 5-in vertical air spaces			
	(4a) 1.75-in wood furring			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(4b) 1.75-in (R-5.6) fiberglass fill wall insulation			
	(5) 0.5-in gypsum wallboard			
217	(1a) 8-in concrete block	(N/A)	5.6	ewcb06nn
	(1b) 5-in vertical air spaces			
	(2a) 1.75-in wood furring			
	(2b) 1.75-in (R-5.6) fiberglass fill wall insulation			
	(3) 0.5-in gypsum wallboard			
Straw Bale Walls				
218	(1) 1-in stucco finish	(N/A)	55.2	ewsb00st
	(2) 23-in straw bale			
	(3) 1-in stucco finish			
Interior Partition Half-Floors				
219	(1a) 5.75-in wood floor joists @ 24 in o.c.	10.0	0	ifwf00ca
	(1b) 5.75-in horizontal air spaces			
	(2) 0.75-in wood underlayment			
	(3) 0.75-in wood subfloor			
	(4) 0.5-in carpet and fibrous pad			
Interior Partition Half-Walls				
220	(1a) 1.75-in wood studs @ 16 in o.c.	25.0	0	iwwf00
	(1b) 1.75-in vertical air spaces			
	(2) 0.5-in gypsum wallboard			
Interior Partition Half-Ceilings				
221	(1a) 5.75-in wood ceiling joists @ 24 in o.c.	10.0	0	icwf00
	(1b) 5.75-in horizontal air spaces			
	(2) 0.5-in gypsum wallboard			
Ceilings below Attics				
222	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	0	ecwf00
	(1b) 3.5-in air spaces			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.5-in gypsum wallboard			
223	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	3	ecwf03
	(1b) 2.5-in air spaces + 1-in (R-3) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
224	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	6	ecwf06
	(1b) 1.5-in air spaces + 2-in (R-6) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
225	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	9	ecwf09
	(1b) 0.5-in air spaces + 3-in (R-9) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
226	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	11	ecwf11
	(1b) 3.5-in (R-11) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
227	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	19	ecwf19
	(1b) 6.5-in (R-19) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
228	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	21	ecwf21
	(1b) 7.5-in (R-21) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
229	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	25	ecwf25
	(1b) 9-in (R-25) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
230	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	30	ecwf30
	(1b) 10.5-in (R-30) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
231	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	38	ecwf38
	(1b) 13-in (R-38) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
232	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	44	ecwf44
	(1b) 15-in (R-44) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
233	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	49	ecwf49
	(1b) 16.5-in (R-49) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
234	(1a) 3.5-in wood ceiling joists @ 24 in o.c.	10.0	60	ecwf60
	(1b) 20-in (R-60) fiberglass fill ceiling insulation			
	(2) 0.5-in gypsum wallboard			
Roofs				
235	(1) 0.25-in asphalt composition shingles	10.0	0	rfwf00co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in sloped air spaces			
236	(1) 0.25-in wood roof shakes	10.0	0	rfwf00wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in sloped air spaces			
237	(1) 0.5-in clay roof tile	10.0	0	rfwf00rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in sloped air spaces			
238	(1) 0.25-in lightweight concrete roof tile	10.0	0	rfwf00lc
	(2) 0.125-in felt building membrane			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(3) 1-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in sloped air spaces			
239	(1) 0.5-in gravel roofing	10.0	0	rfwf00tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 3.5-in wood roof rafters @ 24 in o.c.			
	(5b) 3.5-in sloped air spaces			
240	(1) 0.25-in asphalt composition shingles	10.0	11	rfwf11co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
241	(1) 0.25-in wood roof shakes	10.0	11	rfwf11wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
242	(1) 0.5-in clay roof tile	10.0	11	rfwf11rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
243	(1) 0.25-in lightweight concrete roof tile	10.0	11	rfwf11lc

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
244	(1) 0.5-in gravel roofing	10.0	11	rfwf11tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
245	(1) 0.25-in asphalt composition shingles	10.0	13	rfwf13co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
246	(1) 0.25-in wood roof shakes	10.0	13	rfwf13wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
247	(1) 0.5-in clay roof tile	10.0	13	rfwf13rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(4b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
248	(1) 0.25-in lightweight concrete roof tile	10.0	13	rfwf13lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
249	(1) 0.5-in gravel roofing	10.0	13	rfwf13tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
250	(1) 0.25-in asphalt composition shingles	10.0	15	rfwf15co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
251	(1) 0.25-in wood roof shakes	10.0	15	rfwf15wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
252	(1) 0.5-in clay roof tile	10.0	15	rfwf15rc

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
253	(1) 0.25-in lightweight concrete roof tile	10.0	15	rfwf15lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 5.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
254	(1) 0.5-in gravel roofing	10.0	15	rfwf15tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
255	(1) 0.25-in asphalt composition shingles	10.0	19	rfwf19co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
256	(1) 0.25-in wood roof shakes	10.0	19	rfwf19wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(4b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
257	(1) 0.5-in clay roof tile	10.0	19	rfwf19rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
258	(1) 0.25-in lightweight concrete roof tile	10.0	19	rfwf19lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
259	(1) 0.5-in gravel roofing	10.0	19	rfwf19tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
260	(1) 0.25-in asphalt composition shingles	10.0	21	rfwf21co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
261	(1) 0.25-in wood roof shakes	10.0	21	rfwf21wo

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
262	(1) 0.5-in clay roof tile	10.0	21	rfwf21rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
263	(1) 0.25-in lightweight concrete roof tile	10.0	21	rfwf21lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 7.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
264	(1) 0.5-in gravel roofing	10.0	21	rfwf21tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
265	(1) 0.25-in asphalt composition shingles	10.0	27	rfwf27co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 9.5-in wood roof rafters @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(4b) 2-in sloped air spaces + 7.5-in (R-27) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
266	(1) 0.25-in wood roof shakes	10.0	27	rfwf27wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 9.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 7.5-in (R-27) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
267	(1) 0.5-in clay roof tile	10.0	27	rfwf27rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 9.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 7.5-in (R-27) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
268	(1) 0.25-in lightweight concrete roof tile	10.0	27	rfwf27lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 9.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 7.5-in (R-27) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
269	(1) 0.5-in gravel roofing	10.0	27	rfwf27tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 9.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 7.5-in (R-27) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
270	(1) 0.25-in asphalt composition shingles	10.0	33	rfwf33co

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 11.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 9.5-in (R-33) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
271	(1) 0.25-in wood roof shakes	10.0	33	rfwf33wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 11.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 9.5-in (R-33) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
272	(1) 0.5-in clay roof tile	10.0	33	rfwf33rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 11.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 9.5-in (R-33) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
273	(1) 0.25-in lightweight concrete roof tile	10.0	33	rfwf33lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 11.5-in wood roof rafters @ 24 in o.c.			
	(4b) 2-in sloped air spaces + 9.5-in (R-33) mineral fiber batt insulation			
	(5) 0.5-in gypsum wallboard			
274	(1) 0.5-in gravel roofing	10.0	33	rfwf33tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 11.5-in wood roof rafters @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(5b) 2-in sloped air spaces + 9.5-in (R-33) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
Roofs with Radiant Barriers				
275	(1) 0.25-in asphalt composition shingles	10.0	3.2	rfrb00co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in (R-3.2) radiant barrier spaces			
276	(1) 0.25-in wood roof shakes	10.0	3.2	rfrb00wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in (R-3.2) radiant barrier spaces			
277	(1) 0.5-in clay roof tile	10.0	3.2	rfrb00rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in (R-3.2) radiant barrier spaces			
278	(1) 0.25-in lightweight concrete roof tile	10.0	3.2	rfrb00lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4a) 3.5-in wood roof rafters @ 24 in o.c.			
	(4b) 3.5-in (R-3.2) radiant barrier spaces			
279	(1) 0.5-in gravel roofing	10.0	3.2	rfrb00tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5a) 3.5-in wood roof rafters @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing	Total	DOE-2
No.	Layers	Factor (%)	Insulation (h·ft²·°F/Btu)	Code Name
	(5b) 3.5-in (R-3.2) radiant barrier spaces			
Roofs with Expanded Polystyrene Insulation				
280	(1) 0.25-in asphalt composition shingles	10.0	0 + 5	rfps00co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 3.5-in wood roof rafters @ 24 in o.c.			
	(5b) 3.5-in sloped air spaces			
281	(1) 0.25-in wood roof shakes	10.0	0 + 5	rfps00wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 3.5-in wood roof rafters @ 24 in o.c.			
	(5b) 3.5-in sloped air spaces			
282	(1) 0.5-in clay roof tile	10.0	0 + 5	rfps00rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 3.5-in wood roof rafters @ 24 in o.c.			
	(5b) 3.5-in sloped air spaces			
283	(1) 0.25-in lightweight concrete roof tile	10.0	0 + 5	rfps00lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 3.5-in wood roof rafters @ 24 in o.c.			
	(5b) 3.5-in sloped air spaces			
284	(1) 0.5-in gravel roofing	10.0	0 + 5	rfps00tg
	(2) 0.375-in tar roofing			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5) 1-in expanded polystyrene insulation			
	(6a) 3.5-in wood roof rafters @ 24 in o.c.			
	(6b) 3.5-in sloped air spaces			
285	(1) 0.25-in asphalt composition shingles	10.0	11 + 5	rfps11co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
286	(1) 0.25-in wood roof shakes	10.0	11 + 5	rfps11wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
287	(1) 0.5-in clay roof tile	10.0	11 + 5	rfps11rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
288	(1) 0.25-in lightweight concrete roof tile	10.0	11 + 5	rfps11lc
	(2) 0.125-in felt building membrane			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
289	(1) 0.5-in gravel roofing	10.0	11 + 5	rfps11tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5) 1-in expanded polystyrene insulation			
	(6a) 5.5-in wood roof rafters @ 24 in o.c.			
	(6b) 2-in sloped air spaces + 3.5-in (R-11) mineral fiber batt insulation			
	(7) 0.5-in gypsum wallboard			
290	(1) 0.25-in asphalt composition shingles	10.0	13 + 5	rfps13co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
291	(1) 0.25-in wood roof shakes	10.0	13 + 5	rfps13wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
292	(1) 0.5-in clay roof tile	10.0	13 + 5	rfps13rc

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
293	(1) 0.25-in lightweight concrete roof tile	10.0	13 + 5	rfps13lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
294	(1) 0.5-in gravel roofing	10.0	13 + 5	rfps13tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5) 1-in expanded polystyrene insulation			
	(6a) 5.5-in wood roof rafters @ 24 in o.c.			
	(6b) 2-in sloped air spaces + 3.5-in (R-13) mineral fiber batt insulation			
	(7) 0.5-in gypsum wallboard			
295	(1) 0.25-in asphalt composition shingles	10.0	15 + 5	rfps15co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
296	(1) 0.25-in wood roof shakes	10.0	15 + 5	rfps15wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
297	(1) 0.5-in clay roof tile	10.0	15 + 5	rfps15rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
298	(1) 0.25-in lightweight concrete roof tile	10.0	15 + 5	rfps15lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 5.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
299	(1) 0.5-in gravel roofing	10.0	15 + 5	rfps15tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5) 1-in expanded polystyrene insulation			
	(6a) 5.5-in wood roof rafters @ 24 in o.c.			
	(6b) 2-in sloped air spaces + 3.5-in (R-15) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation ($h \cdot ft^2 \cdot °F/Btu$)	DOE-2 Code Name
No.	Layers			
	(7) 0.5-in gypsum wallboard			
300	(1) 0.25-in asphalt composition shingles	10.0	19 + 5	rfps19co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
301	(1) 0.25-in wood roof shakes	10.0	19 + 5	rfps19wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
302	(1) 0.5-in clay roof tile	10.0	19 + 5	rfps19rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
303	(1) 0.25-in lightweight concrete roof tile	10.0	19 + 5	rfps19lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft^2·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(6) 0.5-in gypsum wallboard			
304	(1) 0.5-in gravel roofing	10.0	19 + 5	rfps19tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5) 1-in expanded polystyrene insulation			
	(6a) 7.5-in wood roof rafters @ 24 in o.c.			
	(6b) 2-in sloped air spaces + 5.5-in (R-19) mineral fiber batt insulation			
	(7) 0.5-in gypsum wallboard			
305	(1) 0.25-in asphalt composition shingles	10.0	21 + 5	rfps21co
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
306	(1) 0.25-in wood roof shakes	10.0	21 + 5	rfps21wo
	(2) 0.125-in felt building membrane			
	(3) 0.625-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
307	(1) 0.5-in clay roof tile	10.0	21 + 5	rfps21rc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			

Table 4. Constructions Modeled in the *Home Energy Saver* (continued)

Construction Type		Framing Factor (%)	Total Insulation (h·ft²·°F/Btu)	DOE-2 Code Name
No.	Layers			
	(5b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
308	(1) 0.25-in lightweight concrete roof tile	10.0	21 + 5	rfps21lc
	(2) 0.125-in felt building membrane			
	(3) 1-in plywood sheathing			
	(4) 1-in expanded polystyrene insulation			
	(5a) 7.5-in wood roof rafters @ 24 in o.c.			
	(5b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(6) 0.5-in gypsum wallboard			
309	(1) 0.5-in gravel roofing	10.0	21 + 5	rfps21tg
	(2) 0.375-in tar roofing			
	(3) 0.125-in felt building membrane			
	(4) 1-in plywood sheathing			
	(5) 1-in expanded polystyrene insulation			
	(6a) 7.5-in wood roof rafters @ 24 in o.c.			
	(6b) 2-in sloped air spaces + 5.5-in (R-21) mineral fiber batt insulation			
	(7) 0.5-in gypsum wallboard			

Table 5. Exterior Surface Roughnesses Modeled in the *Home Energy Saver*

Exterior Covering Type	Surface Roughness
Wood siding, stucco finish, wood roof shakes, tar and gravel roofing	1
Brick veneer, structural brick, concrete block	2
Poured concrete, asphalt composition roof shingles, clay roof tile, concrete roof tile	3
Vinyl siding	4
Aluminum siding	5

Table 6. Exterior Surface Absorptances Modeled in the *Home Energy Saver*

Surface Description	Wall Absorptance (-)	Roof Absorptance (-)
High-reflectance	-	0.40
White	0.35	0.50
Light	0.55	0.65
Medium	0.70	0.75
Medium dark	0.80	0.85
Dark	0.90	0.95

Table 7. Doors Modeled in the *Home Energy Saver*

Door Type			Door U-Factor		DOE-2
Core Type	Edge Type	Frame Type	Nominal (Btu/h·ft^2·°F)	DOE-2 (Btu/h·ft^2·°F)	Code Name
Wood	Wood	Wood	0.46	0.51	www
Insulated steel	Wood	Wood	0.16	0.17	sww
Insulated steel	Metal	Steel	0.37	0.40	sms
Cardboard honeycomb	Metal	Steel	0.61	0.69	cms

Table 8. Windows and Skylights Modeled in the *Home Energy Saver*

Window or Skylight Type			Window U-Factor		Skylight U-Factor		SHGC	SC	DOE-2
Glazing Type	Spacer Type	Frame Type	Nominal (Btu/h·ft²·°F)	DOE-2 (Btu/h·ft²·°F)	Nominal (Btu/h·ft²·°F)	DOE-2 (Btu/h·ft²·°F)	Nominal (-)	DOE-2 (-)	Code Name
Single-pane, clear	(N/A)	Aluminum	1.27	1.69	1.98	3.24	0.75	0.86	scna
Single-pane, clear	(N/A)	Wood or vinyl	0.89	1.08	1.47	2.06	0.64	0.74	scnw
Single-pane, tinted	(N/A)	Aluminum	1.27	1.69	1.98	3.24	0.64	0.74	stna
Single-pane, tinted	(N/A)	Wood or vinyl	0.89	1.08	1.47	2.06	0.54	0.62	stnw
Double-pane, clear	Aluminum	Aluminum	0.81	0.96	1.30	1.74	0.67	0.77	dcaa
Double-pane, clear	Aluminum	ATB[a]	0.60	0.68	1.10	1.40	0.67	0.77	dcab
Double-pane, clear	Aluminum	Wood or vinyl	0.51	0.57	0.84	1.01	0.56	0.64	dcaw
Double-pane, tinted	Aluminum	Aluminum	0.81	0.96	1.30	1.74	0.55	0.63	dtaa
Double-pane, tinted	Aluminum	ATB[a]	0.60	0.68	1.10	1.40	0.55	0.63	dtab
Double-pane, tinted	Aluminum	Wood or vinyl	0.51	0.57	0.84	1.01	0.46	0.53	dtaw
Double-pane, high-solar-gain low-E (e = 0.20 on surface 3)	Aluminum	Wood or vinyl	0.42	0.46	0.74	0.87	0.52	0.60	dpeaw
Double-pane, high-solar-gain low-E (e = 0.20 on surface 3), argon gas fill	Aluminum	ATB[a]	0.47	0.52	0.95	1.17	0.62	0.71	dpeaab
Double-pane, high-solar-gain low-E (e = 0.20 on surface 3), argon gas fill	Aluminum	Wood or vinyl	0.39	0.42	0.68	0.78	0.52	0.60	dpeaaw
Double-pane, low-solar-gain low-E (e = 0.05 on surface 2)	Aluminum	Aluminum	0.67	0.77	1.17	1.52	0.37	0.43	dseaa
Double-pane, low-solar-gain low-E (e = 0.05 on surface 2)	Aluminum	ATB[a]	0.47	0.52	0.98	1.21	0.37	0.43	dseab
Double-pane, low-solar-gain low-E (e = 0.05 on surface 2)	Aluminum	Wood or vinyl	0.39	0.42	0.71	0.82	0.31	0.36	dseaw
Double-pane, low-solar-gain low-E (e = 0.05 on surface 2), argon gas fill	Aluminum	Wood or vinyl	0.36	0.39	0.65	0.74	0.31	0.36	dseaaw
Triple-pane, moderate-solar-gain low-E (e = 0.10 on surfaces 3 and 5), argon gas fill	Butyl-metal	Wood or vinyl	0.27	0.29	0.47	0.52	0.31	0.36	thmabw

[a]ATB is an acronym for an aluminum window frame with a thermal break.

Table 9. Window and Skylight Shades
Modeled in the *Home Energy Saver*

Shade Type	Applicability		Shading Multiplier (-)	DOE-2 Code Name
	Windows	Skylights		
(Unshaded)	•	•	1.00	none
Interior drapes	•		0.25	drapes
Interior roller shades	•	•	0.25	roller
Interior venetian blinds	•	•	0.25	int_blind
Exterior venetian blinds	•		0.15	ext_blind
Exterior sunscreens	•		0.50	screen

Table 10. Foundations Modeled in the *Home Energy Saver*

Foundation Type	DOE-2 Code Name	Insulation Position	Insulation Level ($h \cdot ft^2 \cdot °F/Btu$)	Effective U-Factor ($Btu/h \cdot ft \cdot °F$)
Slab-on-grade	slab	(Uninsulated)	0	0.77
		Perimeter[a] / gap[b]	5	0.54
Unconditioned basement	uncond_base	(Uninsulated)	0	1.94
Conditioned basement	cond_base	(Uninsulated)	0	1.94
		Wall inner surface	11	0.78
		Wall inner surface	19	0.78
Raised basement	cond_base	(Uninsulated)	0	1.61
		Wall inner surface	11	0.79
		Wall inner surface	19	0.79
Unvented crawlspace	unvent_crawl	(Uninsulated)	0	1.29
		Wall inner surface	11	0.91
		Wall inner surface	19	0.91
Vented crawlspace	vent_crawl	(Uninsulated)	0	1.29

[a]Insulation underneath the slab, extending from the exterior edge inward a minimum of 2 ft on all sides.
[b]Vertical insulation between the slab edge and footing stem.

Table 11. HVAC Systems Modeled in the *Home Energy Saver*

System Type	Measure of Efficiency	Comment	DOE-2 Code Name
Heating Systems			
(Unheated)	(N/A)	Simulated as a central gas furnace to prevent a DOE-2 error	non
Central gas furnace	AFUE		gfn
Gas wall furnace	AFUE	Simulated as a central gas furnace	gwf
Propane (LPG) furnace	AFUE	Simulated as a central gas furnace	pfn
Oil furnace	AFUE	Simulated as a central gas furnace	ofn
Electric furnace	AFUE	Simulated as a central gas furnace	efn
Electric heat pump	HSPF		ehp
Electric baseboard heater	AFUE	Simulated as a central gas furnace	ebb
Gas boiler	AFUE		gbl
Oil boiler	AFUE		obl
Cooling Systems			
(Uncooled)	(N/A)		non
Central air conditioner	SEER		cac
Window-mounted air conditioner	EER	Simulated as a central air conditioner	rac
Electric heat pump	SEER		ehp

Table 12. DOE-2 Outputs From the *Home Energy Saver*

DOE-2 Output Report	Outputs Captured
BEPS	Annual energy consumption by end use and utility type
PS-A	Monthly energy consumption by end use and utility type
SV-A	Capacities of HVAC systems other than boilers
PV-A	Capacities of boilers

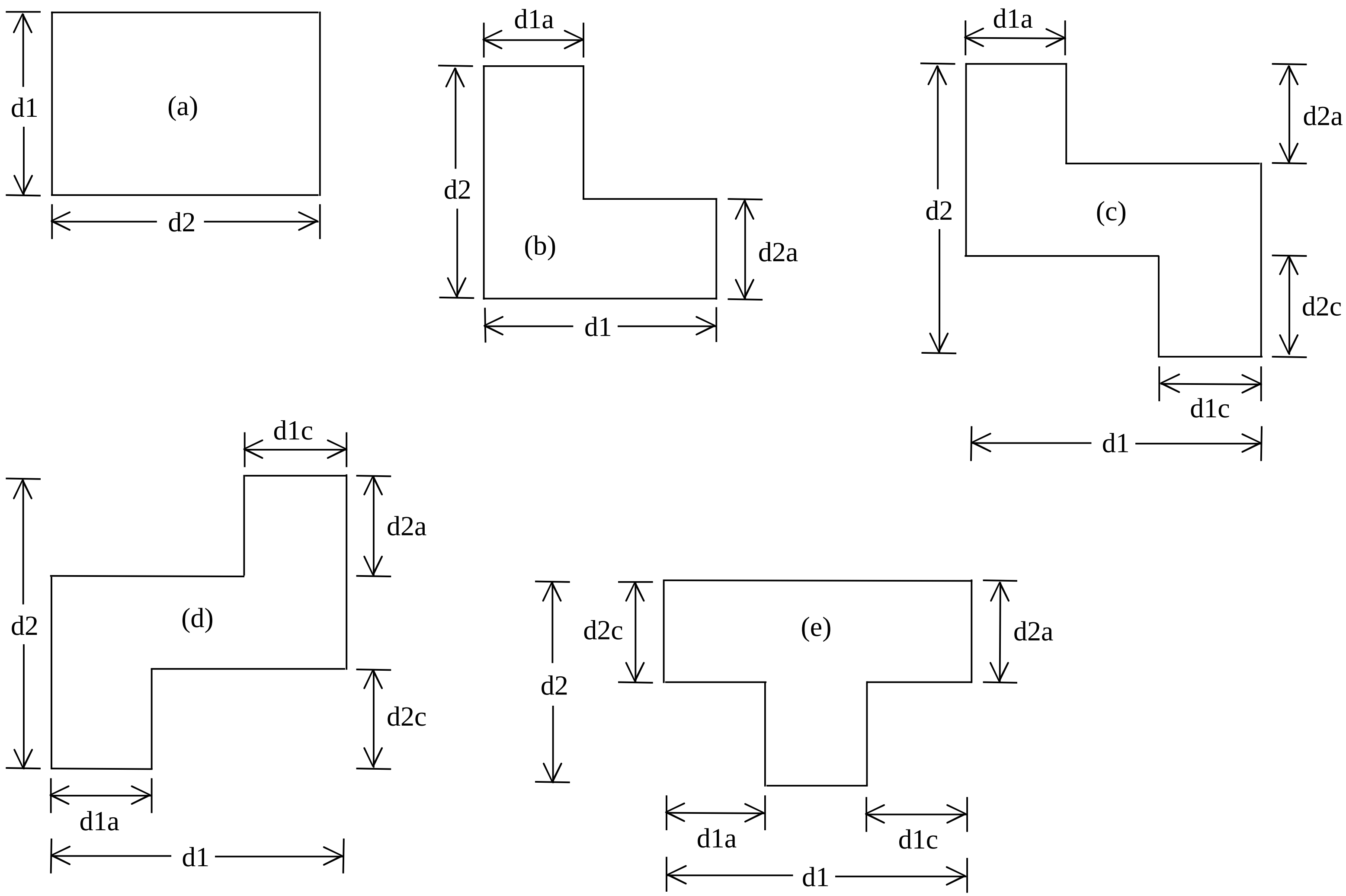

Figure 1. Input dimensions for the house floor plan types modeled in the *Home Energy Saver*: (a) rectangular; (b) L-shaped; (c) forward-S-shaped; (d) backward-S-shaped; and (e) T-shaped.

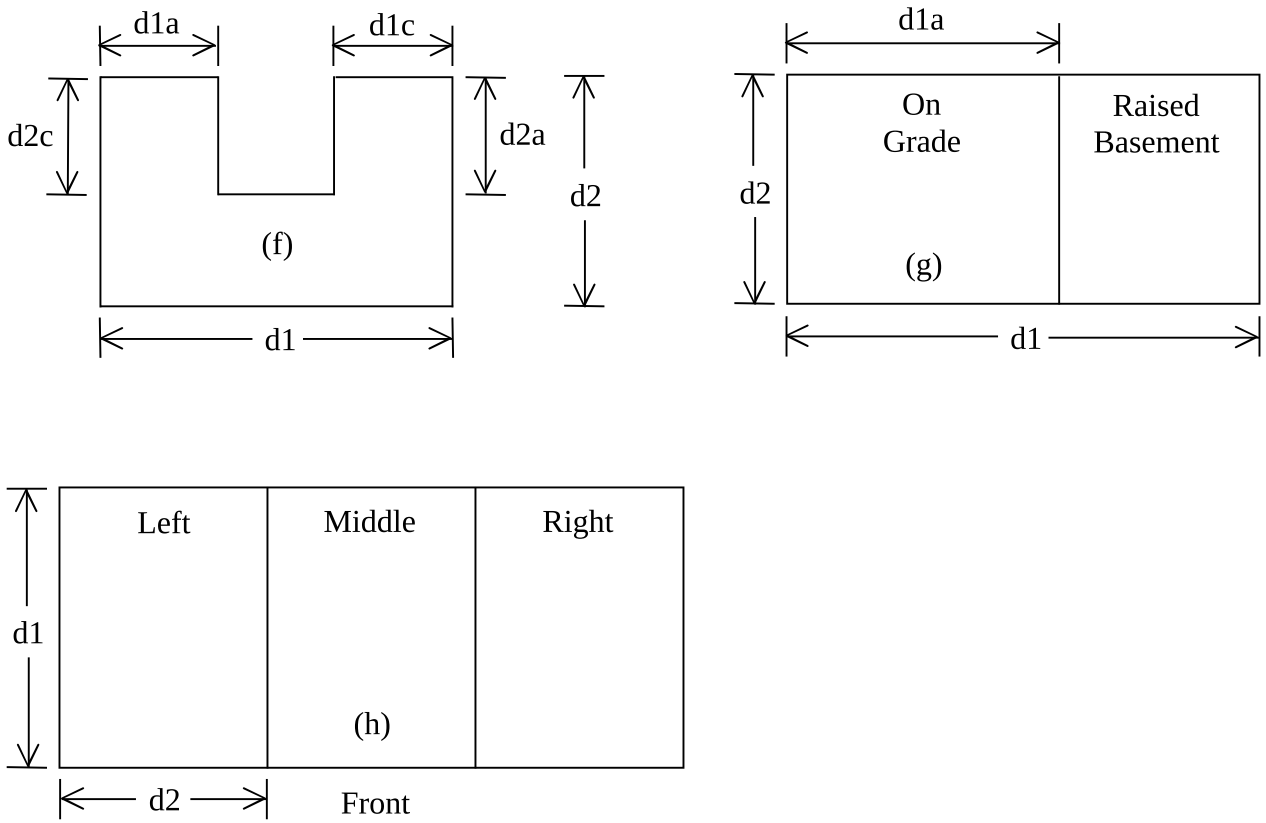

Figure 1 (continued). Input dimensions for the house floor plan types modeled in the *Home Energy Saver*: (f) U-shaped; (g) split-level; and (h) townhouse.

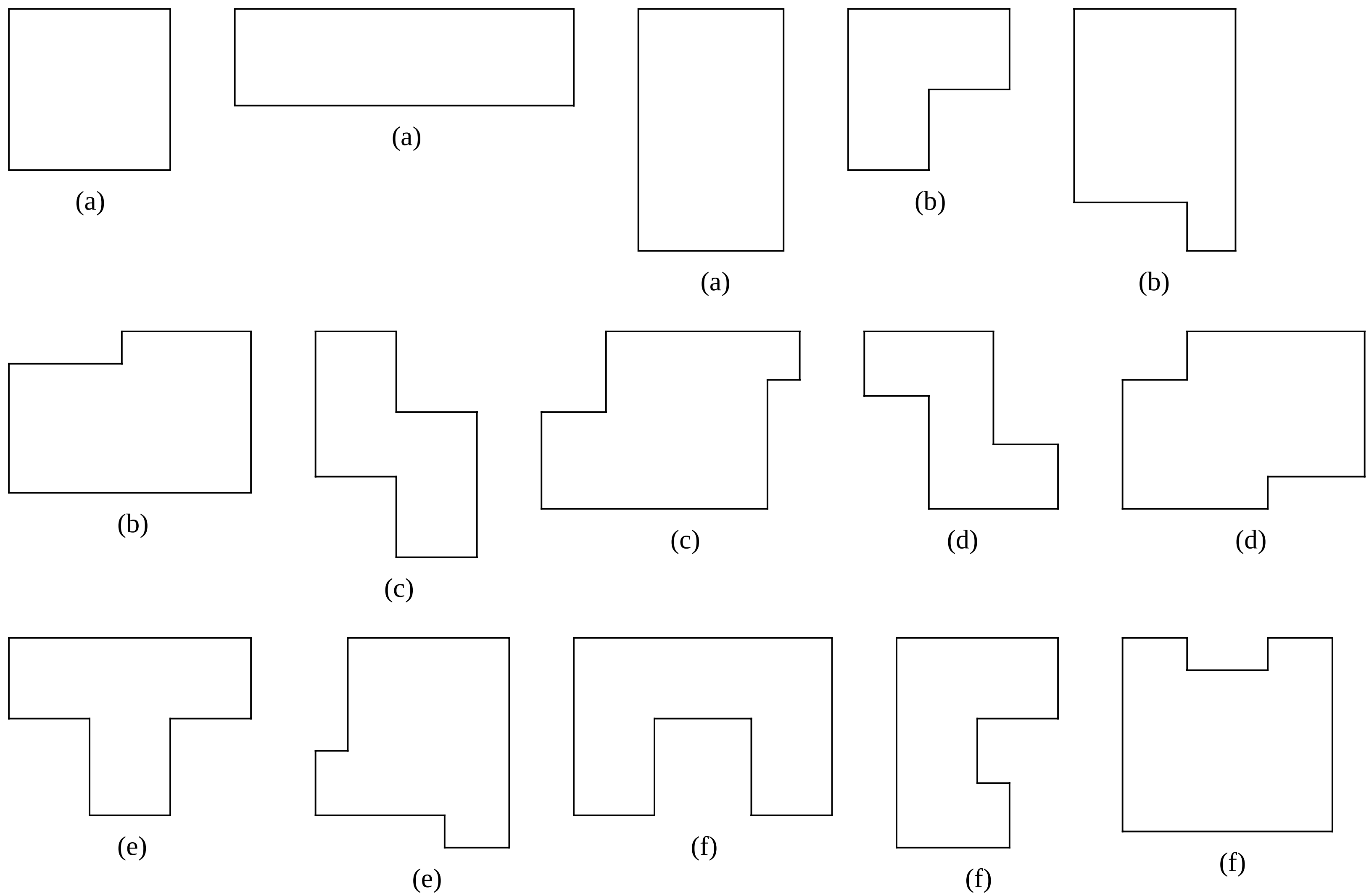

Figure 2. Examples of the variety of house floor plans that can be modeled in the *Home Energy Saver*: (a) rectangular; (b) L-shaped; (c) forward-S-shaped; (d) backward-S-shaped; (e) T-shaped; and (f) U-shaped.

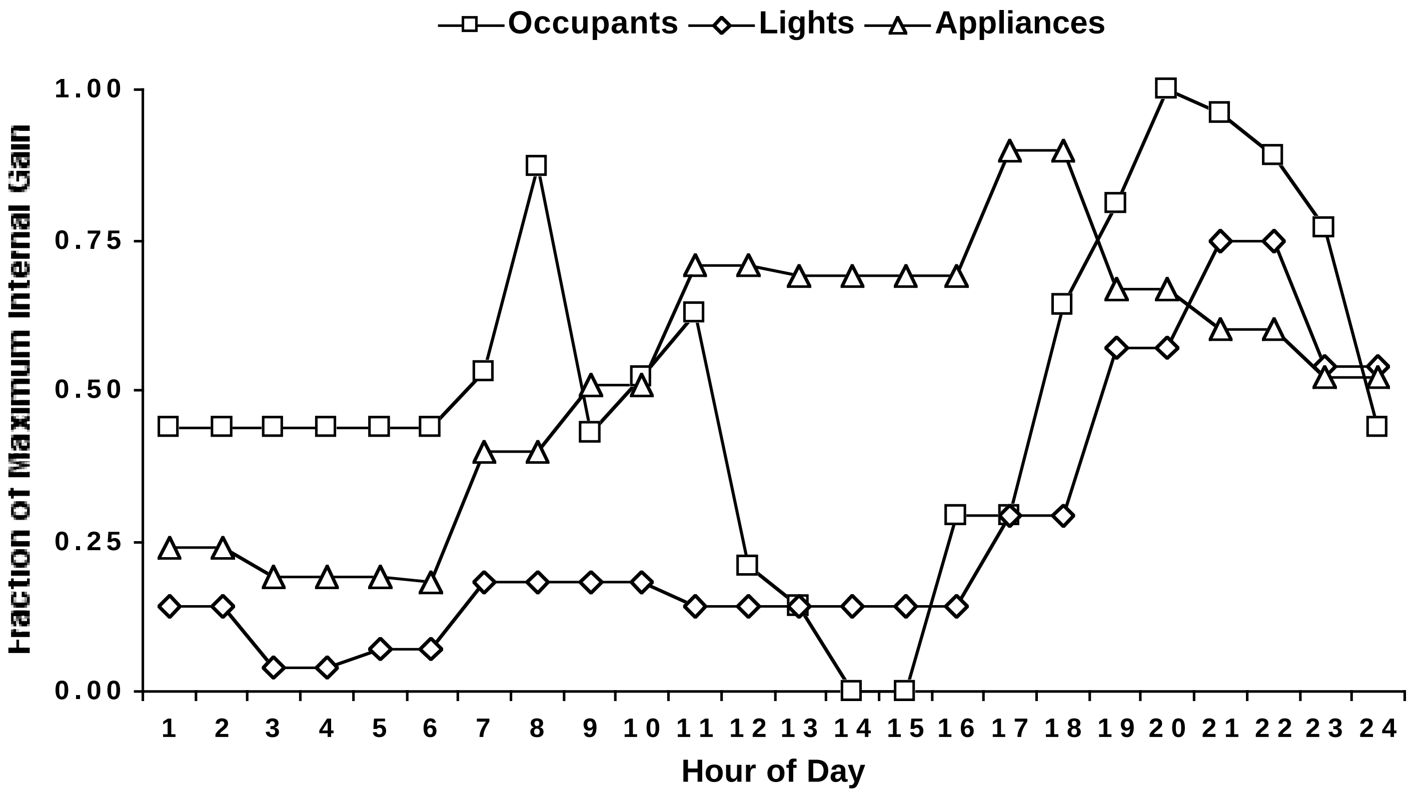

Figure 3. Daily profiles assumed in the *Home Energy Saver* for internal gains generated by occupants, lights, and appliances.